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PUMP DISCHARGE HEADERS AND PUMP PIPING FOR WATER WORKS STATIONS[1]

By F. G. Cunningham[2]

Probably few important features of water works practice have been so neglected and have been developed in such disregard of sound engineering practice as the piping arrangements used to connect the pumps with the outgoing supply mains, commonly referred to as "header systems." Probably not over one out of ten such systems, as installed, is arranged so as adequately to safeguard reliability of service and obtain maximum reliability consistent with the number of valves and fittings used. It is singular that this topic has been almost entirely neglected in technical articles and in the *Manual of Water Works Practice* recently published by the American Water Works Association.

These and the larger membership of the American Water Works Association are the writer's reasons for revising and presenting again this paper which was originally read before the Southwest Water Works Association.

The writer has known of a number of cases, and probably the combined experience of water works men would reveal many others, in which the entire or a major part of a city's supply has been cut off

[1] Presented before the Toronto Convention June 25, 1929.

[2] Of Fuller and McClintock, Engineers, New York, N. Y.

or unreasonably endangered by breaks or repairs in header piping. In one conspicuous case in a large city, valve repairs requiring twenty-four hours of desperate work were completed just as the last water was being taken from the clear water storage reservoir. Had a serious fire occurred during this time a general conflagration might quite possibly have been the result.

Quite a variety of things can necessitate the temporary cutting off of a part of the header system, such as cracks occurring in the cast iron pipes or in valve bodies, need for renewing or repairing parts of the valves, need for making new connections to the system, and similar situations. It should be entirely practicable to perform such routine operations in any header system with facility and without seriously interfering with service.

Consideration of this subject in a specific case must take account of varying local conditions that cannot be dealt with in a general discussion such as this. For example, the presence and amount of elevated or hill-top storage beyond the high service pumps has a direct bearing upon the problem. With enough such storage for many days demand, meager and poorly arranged piping arrangements might still furnish reliable service. Also the number of pumps and of supply mains included in the layout and the number that can be spared without crippling service will influence somewhat the required header arrangements. On the other hand it is obviously unwise deliberately to install header arrangements that might result in shutting down several pumps or several lines even in cases where they might be spared, when a comparatively nominal extra expense or more skill in the arrangement would render such shut-downs unnecessary.

Since most cities have comparatively little or no storage of pressure water, we may assume that for a typical case such storage is absent or too small greatly to be relied upon. Where a considerable amount of it is present the supply that might be obtained from it may be considered in conjunction with that available from the pumping station at the time of the most serious break in the system of header piping, and to that extent might modify the statements about to be made in this paper.

REQUIREMENTS OF GOOD HEADER SYSTEM

Any station should be at least capable of meeting the maximum domestic demand plus fire draft with the largest pump out of service.

Preferably this capacity should be available with the two largest pumps out of service, due to the various conditions such as routine repairs, breaks in steam piping or valves or things of that sort to be expected. Most stations have at least one spare pump and many have two, but few have more. Whatever the number of spare units may be, the writer would point out the obvious inconsistency in providing piping arrangements that might readily throw out of service more than the number of pumps that can be spared. It is also desirable and in some cases strictly necessary that full domestic and fire service be maintained with one of the supply mains, or the portion of it necessarily dewatered in repairing any valve, out of service. Considering these factors and the variations in pumping demand normally to be expected, not less than three pumps and three supply mains are required to present an entirely flexible and satisfactory layout for any case where pressure storage is small or absent.

The functions of a good discharge header may be summarized as follows:

(*a*) To permit any pump, pipe or valve to be isolated for repairs without crippling service.
(*b*) To permit any or all pumps to deliver to any or all supply mains, or at least reasonable flexibility in this respect.
(*c*) To permit ready operation of essential control valves, especially in emergencies.
(*d*) To provide convenient access for inspection and repair of control valves and connecting pipes.
(*e*) To provide reliable and multiple points of connection for essential small water pipes for station service.

The repair or replacement of a valve in a header system is naturally more serious than that of a piece of pipe, since it involves two runs of pipe, that is one on each side of the valve, instead of one run. It is essential, then, to provide two valves between any two adjoining pump connections or supply main connections if it is desired to avoid shutting down more than one unit or line with a single break. With these facts and the above mentioned functions of a good header in mind it is interesting to examine diagrams showing some actual or typical header layouts.

Figure 1 shows a flagrant case of poor arrangement actually installed in a recent project. The entire battery of pumps is connected to a single suction main and a single discharge main without valves except on the branch connections to the pumps. The repair of any

piece of pipe in suction or discharge lines or of any valve would put the entire station out of service.

Figure 2 shows two pumps and two lines with two valves between pumps. One pump and one line would be shut down by any break or any valve repair. If it were not for the two valves between the pumps the entire station would be shut down. This layout is of interest principally in showing that the number of pumps and of lines is too small.

Figure 3 shows three pumps and two lines of which two pumps and one line would be put out of service by repairs to valves "A" or "B."

Figure 4 shows the same thing except that there are two valves between adjoining pumps making it unnecessary to shut down more than one pump and one line with a single break.

Figure 5 shows a three pump layout containing six valves and with a poorly arranged cross connection. Repair to valve "A" would put out of service two pumps and one line. In figure 6 a good layout is shown having the same number of pumps, lines and valves, and with each pump discharge split into a separate valved connection leading to each main. With this arrangement the most serious break cannot shut down more than one pump and one supply main, which result would occur through the repair of any one of the six valves. Figure 7 shows another way of accomplishing the same result as in figure 6 and with the same number of valves. The consequences of the most serious valve repair are the same as in figure 6, except that the chances of such occurrence are somewhat less since there are only four valves that can produce that result instead of six.

Figure 8 shows substantially the same arrangement as figure 7 except that additional valves are inserted bringing the total number up to 11. Under this arrangement two advantages are gained as compared with the others. First, while the repair of certain valves can shut down either one pump or one supply main, no single repair can shut down both a pump and a supply main. Second, connections are such that there is less likelihood of emergencies requiring the stopping of one pumping unit and the starting of another, which operation might be embarrassing.

Figure 9 shows the header layout designed by the writer's firm for Memphis, Tenn. The effect of the most serious single break or repair would be to put one pump or one supply main out of service. Due to the arrangement of cross connections it is possible in this

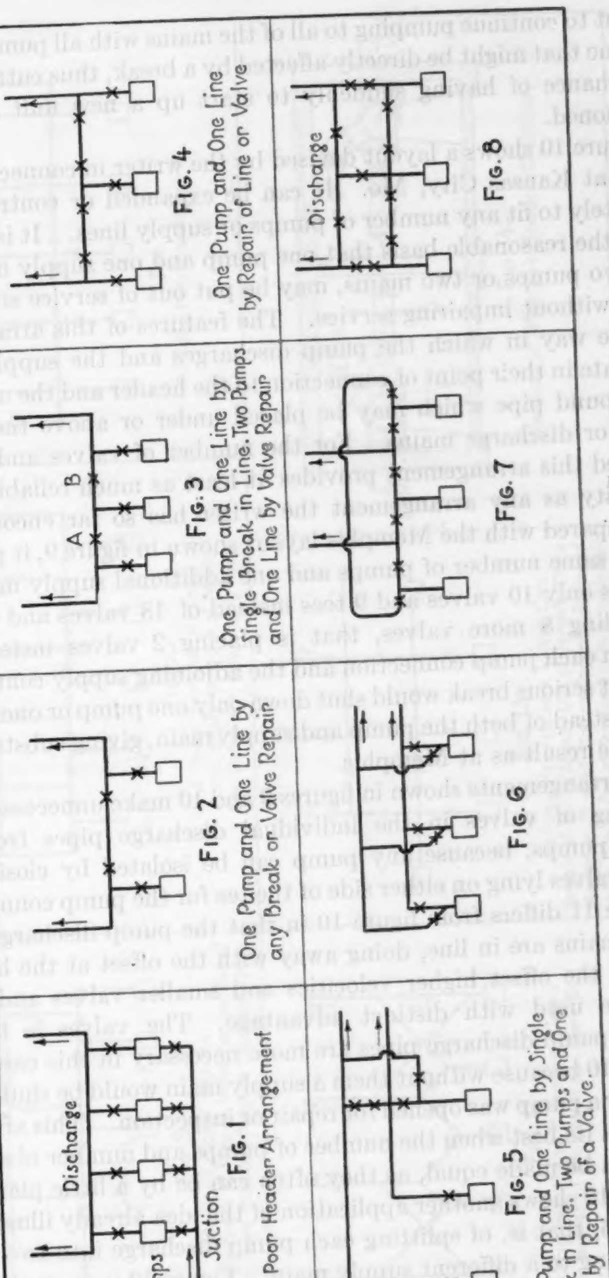


FIG. 1 A Poor Header Arrangement

FIG. 2 One Pump and One Line by any Break or Valve Repair

FIG. 3 One Pump and One Line by Single Break in Line. Two Pumps and One Line by Valve Repair

FIG. 4 One Pump and One Line by Repair of Line or Valve

FIG. 5 One Pump and One Line by Single Break in Line. Two Pumps and One Line by Repair of a Valve.

FIG. 6

FIG. 7

FIG. 8

FIGS. 1–8. ARRANGEMENT OF PUMP HEADER SYSTEMS

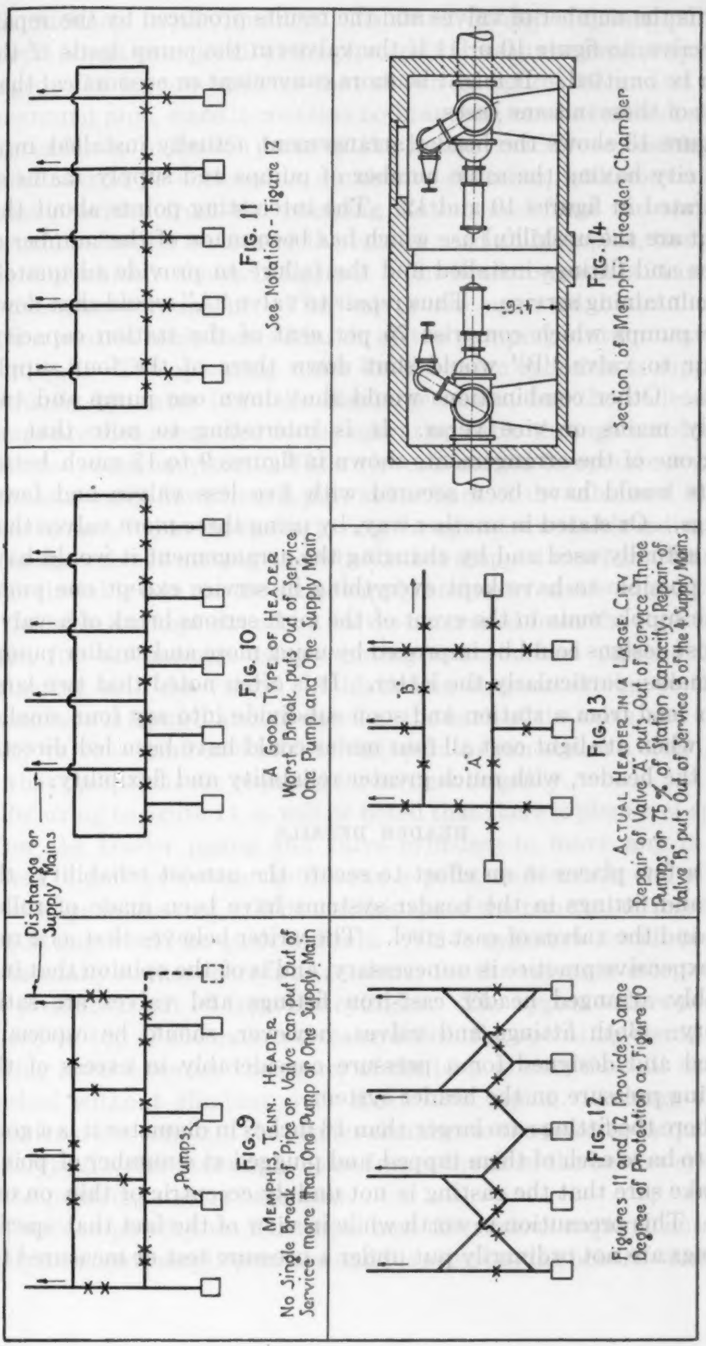
layout to continue pumping to all of the mains with all pumps except the one that might be directly affected by a break, thus cutting down the chance of having suddenly to start up a new unit as above mentioned.

Figure 10 shows a layout devised by the writer in connection with work at Kansas City, Mo. It can be expanded or contracted indefinitely to fit any number of pumps or supply lines. It is founded upon the reasonable basis that one pump and one supply main, but not two pumps or two mains, may be put out of service simultaneously without impairing service. The features of this arrangement are the way in which the pump discharges and the supply mains alternate in their point of connection to the header and the use of the run-around pipe which may be placed under or above the supply mains or discharge mains. For the number of valves and fittings required this arrangement provides at least as much reliability and flexibility as any arrangement the writer has so far encountered. As compared with the Memphis layout shown in figure 9, it provides for the same number of pumps and one additional supply main and requires only 10 valves and 9 tees instead of 18 valves and 12 tees. By adding 8 more valves, that is placing 2 valves instead of 1 between each pump connection and the adjoining supply connection, the most serious break would shut down only one pump or one supply main instead of both the pump and supply main, giving substantially the same result as at Memphis.

The arrangements shown in figures 9 and 10 make unnecessary the providing of valves in the individual discharge pipes from the various pumps, because any pump can be isolated by closing the header valves lying on either side of the tee for the pump connection.

Figure 11 differs from figure 10 in that the pump discharges and supply mains are in line, doing away with the offset at the header. Without the offset higher velocities and smaller valves and pipes might be used with distinct advantage. The valves in the individual pump discharge pipes are more necessary in this case than in figure 10 because without them a supply main would be shut down whenever a pump was opened for repair or inspection. This arrangement is at its best when the number of pumps and number of supply mains can be made equal, as they often can be by a little planning.

Figure 12 shows another application of the idea already illustrated in figure 6, that is, of splitting each pump discharge into two pipes each leading to a different supply main. Figure 12 is equivalent, as



FIGS. 9-14. ARRANGEMENT OF PUMP HEADER SYSTEMS

regards the number of valves and the results produced by the repair of a valve, to figure 10 or 11 if the valves in the pump leads of the latter be omitted. It might be more convenient or economical than either of these in some cases.

Figure 13 shows the header arrangement actually installed in a large city having the same number of pumps and supply mains as illustrated in figures 10 and 12. The interesting points about this layout are the unskillful use which has been made of the number of valves and fittings installed and the failure to provide adequately for maintaining service. Thus repair to valve "A" would shut down three pumps which comprise 75 per cent of the station capacity. Repair to valve "B" would shut down three of the four supply mains. Other combinations would shut down one pump and two supply mains or vice versa. It is interesting to note that by using one of the arrangements shown in figures 9 to 12 much better results would have been secured with five less valves and fewer fittings. Or stated in another way, by using three more valves than were actually used and by changing the arrangement it would have been possible to have kept everything in service except one pump or one supply main in the event of the most serious break of a valve.

Most designs could be improved by using more and smaller pumps and mains, particularly the latter. It is often noted that two large mains lead from a station and soon subdivide into say four smaller ones, when at slight cost all four mains could have been led directly from the header, with much greater reliability and flexibility.

HEADER DETAILS

In a few places in an effort to secure the utmost reliability, the pipe and fittings in the header systems have been made of rolled steel and the valves of cast steel. The writer believes that as a rule this expensive practice is unnecessary, and is of the opinion that in a suitably arranged header cast-iron fittings and valves are satisfactory. Both fittings and valves, however, should be especially rugged and designed for a pressure considerably in excess of the working pressure on the header system.

Where the fittings are larger than 16 inches in diameter it is a good plan to have each of them tapped and plugged at a number of points to make sure that the casting is not unduly eccentric or thin on one side. This precaution is worth while in view of the fact that special castings are not ordinarily put under a pressure test or measured for

wall thickness in the foundry. To avoid danger of joints pulling apart it is best to make all of the pipe and valves in the header system flanged. In layouts such as that shown in figures 10 and 11 the run-around pipe, since it contains no branches, can be made of steel.

In order to make all parts of the header readily accessible the header should be enclosed in a masonry chamber, with convenient access provided from the pumping station and from the surface. Figure 14 shows a section of the header used at Memphis, the plan layout of which is shown in figure 9. The header system is 24 inches in diameter throughout. The valves are operated hydraulically from a control table located inside of the pumping station near the front wall. The operating water for the valve cylinders is supplied ordinarily by water from the discharge mains, but the boiler feed pumps are also connected to the operating table through a reducing valve for emergency use. When a lever is moved to operate a valve the waste water flows from a pipe at the back of the table and into a funnel connected to the sewer, giving the operator a visible indication when the valve is moving and when it has stopped moving. Except when the table is in use the water supply and water waste connections to the table are kept cut off by valves controlled from the top of the table, for the purpose of preventing unauthorized persons from tampering with the valves. A black line diagram similar to those shown here is framed and mounted at the back of the table and on it every valve is numbered so that the operator can secure a clear idea of what operations are required for any contingency.

Referring to figure 14, it will be noted that there is plenty of space below the header piping and valve cylinders to move any of the valves or fittings across the floor to a point underneath one of the hatchways in the roof. Without this space the removal or insertion of a fitting would be quite difficult. Valve cylinders are all placed horizontally so that there is no tendency for the valves to creep when the pressure is cut off from the cylinder. The bypass valves are all placed on top of the main valves and with the operating stems projecting inward toward the center of the loop so that they all can be reached without climbing over the header piping. A large drain leads from one corner of the header chamber to the sewer so as quickly to carry off water that might come from a break in the header system or the pumping station basement.

The Memphis layout illustrates how the various requirements for ready and convenient operation and for access to the header were met

in this one case. Whether hydraulic or electric valves should be used in a given case as against hand operated valves, depends considerably upon the number and size of the valves, but there is no doubt that even in small sizes power operation is advantageous and will speed up the valve operations necessary in emergencies. Hydraulic valves are cheaper than electrically operated valves and if connected to the boiler feed pumps or some similar emergency source of water supply, are probably more dependable as to source of power supply in most stations.

It is often advantageous to use high water velocities and relatively small pipe and valves in the header system. This not only keeps down the cost but promotes quickness of operation, ruggedness and reliability as compared with larger piping. In any of the loop arrangements such as shown in figure 10, water ordinarily flows both ways around the header, and normally velocities are moderate. When the loop is interrupted by closing valves, velocities will be high, but considering the short time such conditions exist and the advantages to be gained by the smaller sizes a few feet of extra head loss is not a powerful factor.

Except as the need for reliability may be modified by the presence of low service storage, low service discharge headers should be laid out with the same care as high service headers.

SUCTION CONNECTIONS

On account of the low pressure on the suction side of the pumps and of the greatly lesser likelihood of breaks occurring there, it is unnecessary to have suction arrangements anything like as thoroughly valved and as complex as the discharge header. There are certain criteria however which should be met. The suction connection from each pump should lead directly to the suction well or to a concrete conduit, which may be regarded as the equivalent of a suction well, independently of the other pumps. The suction pipe for each pump should project several feet below the lowest water level in the suction well or suction conduit so that the pump may be primed or started or stopped without interfering with the suction to the other pumps. If these requirements be met about the only other requirement to be considered is that it should be made possible to gain access to one part of the suction well or suction conduit and to the individual pipes connected thereto without interrupting service of the remaining pumps. At Memphis there are two separate suction conduits, one

arranged to supply three pumps and the other two pumps. Each conduit is controlled by a sluice gate and each sluice gate by double stop-plank grooves, so arranged that either sluice gate or either suction conduit can be isolated without shutting down more than half of the pumps normally available.

Under other circumstances the same effect could be produced with a single suction conduit merely by placing stop-plank grooves at intervals along the length of the conduit and by feeding the conduit from both ends. This is done in the Dallas design where the grooves divide the conduit into three parts, and where the grooves are covered with plates set flush with the basement floor and designed to take the uplift of a full clear water basin. In this case the basin will be lowered when the conduit is to be entered.

The above described suction arrangements are probably sufficient for the average case. For one thing they eliminate the most common fault in suction piping which is to connect the pumps to a single vacuum suction header invariably resulting in troubles in priming the pumps or in keeping them primed during operation.

Foot valves in suction connections are to be avoided, first, because they introduce in an inaccessible location a device likely to require attention and repair, and second, because they are likely to subject the pumps and suction piping, especially centrifugal pumps, to severe shocks caused by water hammer when the checks close.

CHECK VALVES

Check valves on the discharge side of centrifugal pumps are practically essential in all ordinary cases. In one case where they were omitted a sudden tripping of the pump, and the resulting back flow of water at high velocity, burst the pump casing. Another danger when check valves are omitted is that the back flow of water will over-speed the pump and cause damage through centrifugal stress before it can be shut off.

For these reasons check valves in the discharge lines of centrifugal pumps seem to be a necessary evil, although the way in which some of them slam shut and cause water hammer when the power is cut off, is a matter of concern to many operators, particularly where the valves are 24 inches or more in diameter. Relief valves should be provided where the danger of hammer is great. After experiencing this difficulty in a number of installations, the writer took up with a valve manufacturer the question of designing a valve which would

close with less shock. A multi-port valve was required and it was decided to depart from the standard design of that manufacturer to the extent of increasing the number and cutting down the diameter of the ports and making the flaps of a tough bronze instead of bronze faced cast iron. The reduced weight of the flaps and the reduced distance through which they traveled in closing apparently produced a good result as these particular valves close without noise even when the pump is suddenly tripped. Of course the Larner-Johnson, automatic cone or other special combination stop and check valves can also be used to prevent hammer and can be used in sizes much too big for a good gate or check valve. The writer has seen fit to mention this detail because the shocks in many such lines are a serious potential source of unreliability.

The foregoing discussion of headers and pump piping is offered on the basis that it may point out proper methods of approaching the subject rather than with the idea that it will afford a suitable layout fitted to each particular case. Local conditions must be considered in all cases. In every case, however, authorities responsible for planning the piping arrangements should submit their proposed arrangements to the insurance inspection department having local jurisdiction. In all cities above 25,000 population, the National Board of Fire Underwriters, through its Engineering Department, makes a detailed study of the entire water system and it is highly desirable that their criticisms should be secured before the work is built. They are in possession of an abundance of information and know the good and bad features of all important water systems in the country as viewed particularly from the standpoint of reliability of service.

DISCUSSION

John Chambers:[3] The Louisville Water Company has corrected a faulty condition in pump discharges which may be of interest to members of the Association.

The Repumping Station, known as the Crescent Hill Pumping Station, was originally designed for four pumping engines and all of these have been in service since 1920. The first two were installed by the Holly Manufacturing Company and were placed in service in June and July, 1907. A third pumping engine was completed the latter part of 1908 by the same manufacturer. These are of 24

[3] Louisville, Ky.

m.g.d. capacity each and of triple expansion type. A fourth pumping engine of 40 m.g.d. capacity was erected in 1919 by the Worthington Pump and Machinery Corporation.

These four pumping engines discharged into a common header which was ungated within the limits of the pump house. The National Board of Fire Underwriters repeatedly called the Louisville Water Company's attention to the hazard of this single, ungated discharge header. It is of cast iron, supported on concrete columns. The metal is 2¼ inches thick and the header has never shown any evidence of weakness or leakage. It is 60 inches in diameter and it is obvious that any failure within the station would have thrown the entire pumping equipment out of commission.

The planning of the proper relief was complicated by the limited space between the original discharge header and the wall of the pumping station. The final plan provided for the installation of a second header 48-inches in diameter. This header was also made of cast iron. Connections are provided for each pump to the new header and each connection is controlled by a valve. At the center of each header a gate valve is located. With this arrangement any break in a pipe line within the pumping station will put out of commission no more than one-fourth of the header system, and each pump can now be isolated from a broken header and deliver water through the adjacent header as soon as valves can be operated.

The National Board of Fire Underwriters has approved of this new arrangement and it is believed that there was practically no other solution of the problem.

The plans were prepared by Messrs. Alvord, Burdick & Howson, Engineers. The installation was made by the Louisville Water Company's forces, under the direction of an erecting engineer borrowed from the International Filter Company.

A. Cary Hutson:[4] Mr. Cunningham's paper is probably one of the most interesting papers I have heard. In the twenty years we have reviewed water supply situations, I think we have faced every combination that could exist. Probably the most complicated one was the old Buffalo system, in the discharge header of the Massachusetts Avenue pumping station. In the endeavor to permit flow from any pump to any of the several discharge mains it was so compli-

[4] New York, N. Y.

cated that even when you had a diagram in front of you you could not tell where your pipes went and what they did, but that has been improved. It is not necessary to carry the system with that degree of complexity, but it is desirable to make it as Mr. Cunningham has recommended. It is one of our duties to make a study of header systems in every city we inspect. There are not more than one or two percent of the cities we have inspected where the repair of a single valve would not put out of service about fifty percent of the stations. Apparently the need of repairing valves is not sufficiently frequent to call that to the attention of the operating head. I know of one case on Long Island, in a small station, where they went to operate a valve, and the man attempted to operate it in the opposite direction, and twisted the stem off. In order to repair that valve, the station was out for 48 hours. It was not just in order to repair that valve, however, but because of the serious complications that came up. In isolating that one valve he shut down another and broke it. The valves around a pumping station are not operated very frequently. I have in mind a valve outfit that I inspected where, from the indication of rust and other things, I do not believe it could have been operated. I am sure that if you attempted to operate one of the main valves it would be necessary to repair it afterwards, and it would have put the entire station out.

Mr. Cunningham brought this subject up about a year and a half ago and asked if we had any ideas on it. We told him we had a lot of ideas on it, but that we would much rather he worked out the ideas himself. We gave him a few thoughts, and I am certainly glad to see such a well prepared paper. I hope it will satisfy everybody because there are many stations where valving can be improved.

L. A. Day:[5] Mr. Cunningham considers it wise to insist on very heavy fittings at his header and extra piping. He recognizes that cast iron was undoubtedly extra heavy pipe, and he wants to have the flange joint as heavy as possible, and that the entire machine job on this header should be just as accurate and as well proportioned as possible so as to minimize the strain. With that in mind he has a minimum of interruption of service. We have had continuous experience with large valves and duplicate headers. Some of these valves were not operated as they should have been, and some of them were placed in bad positions. In addition, our water some-

[5] St. Louis, Mo.

times creates a scaly deposit in the joint. These valves were in a horizontal position and they would not function, and we came to the conclusion that they were not properly designed for this service. They were known as the double disk type of valve, and when they were placed horizontally the mechanism in the valve was such that they would not function when they were opened. The wedge mechanism would drop down in the reverse direction, and the valve would stick closed. We have corrected that. We communicated with the valve manufacturer and we found we could overcome that trouble. It seems to me that the solid wedge valve with machine guide is the best valve for header construction. We went so far in our new plant as to use steel valves and steel fittings on the assumption that even if one did develop a fracture, perhaps due to poor work in the shop or foundry, it would be more easily repaired than a cast iron valve. We would have some warning because it would never rupture like a cast iron valve. We provided when we started the new plant a steel casting in our manifold which we thought was perfect, but it developed a leak. On a careful analysis we saw that it was a foundry fault, so we welded it without taking it out of its place, and we have tested it again and we feel that it is safe.

The matter of check valves is also very important, especially with the advent of the centrifugal pump together with water hammers which we experienced more than we did with the steam pump.

Mr. Cunningham said that a great deal of thought could be given to a proper type of check valve. When you shut down a centrifugal pump, particularly a motor driven pump, the water hammer is enormous, and in our plant we have installed a valve of the type mentioned in Mr. Cunningham's paper which closes before the water ceases to pump, and in that way we get practically no water hammer.

A MEMBER: We have a rather small pumping station. We pump a million and a half gallons per day. Some years ago when our first turbine pump was installed the power was off and as a result a water hammer took the end out of the turbine pump. After that we equipped all our turbine pumps with automatic relief apparatus similar to a safety valve. In one or two cases where space was not available for installation of the valve, we had the manufacturer prepare a special flange on the top of the check valve to which we bolted a spring rod relief valve. These valves, in case of power interruption, which is not often, will open and the resulting water hammer

is dissipated through the relief hammer. We have used feed valves on turbine pumps and we find it a decided advantage in that it retains the priming in the pump. Some times it is a saving to have the priming already in the pump, because there is more or less delay in priming the pump. We have sufficient storage capacity for twelve hours, and we can repair our machinery while we use that water. We have found a foot valve is a great saving of time particularly in the case of fire.

A. P. Pigman:[6] That is especially useful where you are pumping at a low head. We have one station where we are pumping about six feet and it costs us $500 a year to pump through that check valve. We have weights put up in such a way as to balance the gates and reduce the friction. We check this up on one check valve where we had a loss of two feet, and putting the one weight on made a difference of an eighth of an inch. On the other hand by putting the weight the other way so that it caused the gate to close just before the water ceased to flow it eliminated the water hammer completely.

Certainly there is no doubt that Mr. Cunningham's solution of the check valve with very light flappers solves all the problems at once.

John F. Laboon:[7] Mr. Cunningham has brought out important points in relation to the check valve. I find upon investigation that very few manufacturers of check valves really can tell you how much loss will be experienced by the various types they manufacture under varying conditions of outflow. I have measured that in several places, particularly at Erie and Wheeling. In the multiple type of check valve, where they have a strong disk similar to the design of the pump check, the loss amounted to about 2½ feet at the capacity of the pipe line.

In another place where a centrifugal pump was installed and there was no check valve, they wondered why the output of the pump could not be realized. They found there was 7 or 8 feet of head loss in the check valve. It amounted to 10 percent of the total pump head.

The Chairman: That point is important. We would pay a very much higher price for a check valve if we had less friction loss, especially when we are paying a fairly high price for the power.

[6] New York, N. Y.
[7] Pittsburgh, Pa.

THE USE OF PUMPERS AT FIRES[1]

By Clarence Goldsmith[2]

The furnishing of water in quantities required for fire extinguishment in built-up communities in the United States is the function of the waterworks system, which in most cases furnishes domestic supply and nearly all manufacturing process requirements. In some fifteen cities separate fire main systems have been installed, either because the enormous concentration of values warranted the additional expense of this special protection or because it was not economically feasible to secure the desired adequacy and reliability by strengthening and making additions to the existing domestic water systems.

It is distinctly a function of the fire department to apply the extinguishing medium, whether it be chemicals, inert gas, or water on the fire and thus extinguish it. This department must, necessarily, be equipped with requisite devices and mechanical appliances to do this.

During the past century, in which period water systems were developed to supply domestic supply and fire protection, many such systems were so designed that pressures sufficient to develop direct hydrant hose streams were provided. These pressures were constantly maintained on the system when the topography was such that a distributing reservoir could be built at a suitable elevation, and, in other cities not so favorably situated, the pressure was raised at time of fire by direct pumpage. In the larger cities this was more or less impracticable and the steam fire engine was developed and used by the fire department to secure sufficient pressure.

FIRE STREAM REQUIREMENTS

In order that our problem may be clearly before us, the requirements for the various kinds and sizes of fire streams needed under different conditions met in practice will now be reviewed.

[1] Presented before the Indiana Section meeting, February 28, 1929.

[2] Assistant Chief Engineer, The National Board of Fire Underwriters, Chicago, Ill.

At a given pressure a good fire stream is one, which, at limit named, would enter through a window and barely strike ceiling with force to spatter well, and which at limit named had not lost continuity of section by dividing into a shower of spray, and which at this limit shoots nine-tenths of the whole body of water inside a 15-inch circle and three-fourths of it through a 10-inch circle.

A common formula used to calculate the height of a fire stream is

$$H = \sqrt{240\ p - p^2 - 1{,}900} - 15$$

where H = height in feet and p = pressure in pounds at the base of the playpipe. (For 50 pounds or less, subtract 1 from 15 for each $\frac{1}{8}$-inch increase in nozzle diameter above $\frac{3}{4}$-inch. For pressures above 50 pounds, subtract 2 from 15 for each $\frac{1}{8}$-inch increase in diameter above $\frac{3}{4}$-inch.) This formula is applicable only to fire streams having nozzle pressures up to 120 pounds.

From a practical fire-fighting standpoint the maximum vertical reach of an effective fire stream is 100 feet. For instance, the vertical reach of a stream from a $1\frac{1}{2}$-inch nozzle at a pressure of 50 pounds is 79 feet and at 60 pounds is 87 feet, which shows an increase in elevation of 8 feet for an increment of 10 pounds in pressure, but at a pressure of 80 pounds the vertical reach is 96 feet, and at 90 pounds, 100 feet, showing an increase of only 4 feet for an increment of 10 pounds pressure. The maximum elevation of the effective stream is reached at about 130 pounds for higher pressures produce such velocities that the friction of the air tears the stream as soon as it emerges from the nozzle tip.

Two and one-half inch lines with $1\frac{1}{8}$-inch shut-off nozzles are ordinarily used for inside hand lines and pressures from 25 to 30 pounds deliver fair streams; from 35 to 45 pounds, good streams; and from 50 to 60 pounds, excellent streams. Such lines can be easily held and directed for the pull-back, or reaction, if the line is not excessive. At 45 pounds pressure the pull-back of a $1\frac{1}{8}$-inch smooth nozzle is 95 pounds. The pull-back of any hose line, when the nozzle pressure and the diameter are known, can be calculated as follows: Square the diameter of the nozzle, multiply the result by the pressure in pounds, and this result by $1\frac{1}{2}$.

One and a quarter inch and $1\frac{1}{2}$-inch tips usually used on siamesed $2\frac{1}{2}$-inch lines or single 3-inch lines are generally directed from outside of buildings into the building on fire or from the window or roof of a building on to a building which is afire. In any case, such lines are

ordinarily fixed in position and are supplied with holders or jacks to take up the reaction of lines so that they can be easily held and directed on the fire with safety. Pressures from 65 to 80 pounds are needed on such lines. One and three-quarter inch, 2-inch, and 2¼-inch streams are ordinarily supplied by deluge sets, wagon pipes, deck pipes, monitor nozzles or water towers, and such streams may well have from 90 to 100 pounds pressure at the nozzle.

Our "Manual of Water Works Practice" states that a normal static pressure of from 60 to 75 pounds per square inch on a water distribution system is now considered desirable. It presents the following advantages:

(*a*) It will supply ordinary consumption for buildings up to 10 stories in height.
(*b*) Gives effective sprinkler service in buildings of 4 and 5 stories.
(*c*) Permits direct hydrant service for a few hand hose streams at the lower elevations, insuring quicker operation by the fire department.
(*d*) Allows a lower margin of fluctuation in lower pressures in meeting sudden drafts, and offsets loses due to partial clogging or excessive length of service pipes.

It is not feasible to carry normal domestic pressures or raised pressures at time of fire so that they will be sufficient to develop the hose streams required to fight a fire of any considerable proportions. Other means must be employed to develop the required fire streams.

THE AUTOMOBILE PUMPER

Up until 1910 the steam fire engine was utilized by municipal fire departments to raise pressures to deliver fire streams. At this time the development of the gasoline, engine-driven, automobile pumper started. At the Thirty-ninth Annual Convention of the International Association of Fire Engineers, held at Milwaukee in 1911, it was voted to appoint a committee to formulate a definite plan for testing motor pumpers. This committee collaborated with the engineers of The National Board of Fire Underwriters and adopted what was then known as the "Endurance Test," but what is now commonly called the "Twelve-hour Test." This test consists of operating the pumper at capacity against 120 pounds net pressure for six hours, at one-half capacity against 200 pounds pressure for three hours, and at one-third capacity at 250 pounds pressure for three

hours. Considerable credit is due this committee for its decision, for during the eighteen years which have intervened since that time and during which motor apparatus has been brought to its present degree of perfection, it has not been considered necessary or desirable to modify the requirements of this test.

Most cities include in their contract and specifications that a pumper shall pass a three-hour acceptance test which is commonly known as the "Underwriters' Test." This test consists of operating the pumper at its rated capacity against 120 pounds net pressure for two hours, at one-half its rated capacity against 200 pounds net pressure for 30 minutes, and at one-third its rated capacity against 250 pounds net pressure for 30 minutes. Such tests are made at the request of an official of the city purchasing the apparatus by either engineering representatives of the National Board or of the stock fire insurance rating bureau having jurisdiction; no charge is made for this service.

These tests have had a very beneficial influence on the development of the motor pumper and there are few manufacturers in the field today who do not call for the 12-hour test on new types and designs of pumpers which they manufacture or assemble, and they specify the 3-hour acceptance test in their contract.

For service in towns and cities having populations in excess of 10,000, pumpers having capacities of 750 gallons or more are best adapted to the requirements. Such apparatus must necessarily be designed and constructed for the special service which it is called upon to perform, and the service record of such apparatus over a period of years clearly demonstrates that the equipment so designed and constructed is vastly superior to that made up of units of various manufacturers and assembled. Today, this is hardly true of pumpers having capacities less than 750 gallons. Within the past ten years, commercial motor truck and bus chassis and their engines have been developed to such a degree of perfection that many manufacturers have utilized these chassis in assembling motor pumpers. This has led to an extensive diversification of types and capacities of pumpers. A number of manufacturers and assemblers, realizing the desirability of standardizing pumper capacities, have formed a Simplified Practice Committee and are coöperating with the Department of Commerce in establishing standards for fire engine pumping capacities. At the present time the committee recommends the following standards:

500 gallons per minute at 120 pounds pressure per square inch
750 gallons per minute at 120 pounds pressure per square inch
1000 gallons per minute at 120 pounds pressure per square inch

However, because of the fact that small towns, villages, and rural districts frequently do not have the financial capacity to purchase pumpers of these capacities, and in some cities water supplies in many instances are not sufficient to deliver these pumper capacities, the committee has recognized the following capacities for use where they are adapted:

300 gallons per minute at 120 pounds pressure per square inch
400 gallons per minute at 120 pounds pressure per square inch

The National Board of Fire Underwriters has recently revised its "Specifications for Gasoline Automobile Fire Apparatus," and it is strongly recommended that any city or town contemplating the purchase of fire apparatus use these specifications as a guide in purchasing apparatus.

During the past ten years the gasoline, engine-driven pumper has reached a stage of development where there is little or no question of its reliability. Waterworks officials and fire chiefs realized that the pressures needed to fight fires could be much more economically developed by utilizing pumpers than by raising fire pressures on water distribution systems and, therefore, the practice of raising pressures has been discontinued on many systems, thus relieving waterworks of a considerable expense and responsibility besides cutting down the probability of the failure of the distribution system due to raising pressures.

PUMPERS AND FIRE HYDRANT REQUIREMENTS

In order to concentrate the required quantities of water when direct hydrant hose streams are used, it is necessary to have a much closer spacing of hydrants than is needed when pumpers are used. For instance, where a fire flow of 3,000 gallons is required, a hydrant must be provided for each 70,000 square feet of area in order that two-thirds of the quantity can be concentrated on the building or group of buildings requiring protection. If pumpers are used, only one hydrant to each 100,000 square feet of area is needed in order to concentrate the same quantity of water.

Pumpers are provided with suction hose and reducers so that suction may be taken either from 2½-inch hydrant outlets or 4½-

inch steamer outlets; however, in order to supply a 750-gallon pumper, which is the ordinary capacity in service, hydrants should have 4½-inch outlets with National Standard thread. When pumpers are purchased and put in service in cities which have been dependent on hose streams and have hydrants with only two 2½-inch hose outlets, if it is desired to operate a pumper up to its capacity, it is necessary to provide the pump suction with a wye connection so that a 2½-inch suction can be connected to each 2½-inch outlet.

It is important that hydrants be of such design that the friction loss in them is not excessive. They should be able to deliver 600 gallons a minute with a loss of not more than 2½ pounds in the hydrant, and a total loss of not more than 5 pounds between the street main and the outlet. The importance of keeping the friction loss in a hydrant to a minimum is almost of as much importance when pumpers are used as when direct hydrant hose streams are used.

CAPACITY OF PUMPERS

The pumper's capacity, if of proper design, is limited by the power which the gasoline engine can develop. In actual operation at large fires where a number of pumpers are required, the pressure at many of the pumpers, particularly those which are at a considerable distance from the fire, should be in the neighborhood of 200 pounds. Therefore, it will readily be seen that, if the pressure on the suction side of the pump is reduced to zero, the capacity of the pumper is reduced one-half, whereas, if a pressure of say 50 pounds can be maintained from the water distribution system on the suction side of the pump, the capacity is reduced only one-third.

In cities which are supplied by domestic water systems which are able to deliver the full fire flow at 75 pounds pressure, it is necessary to have pumper capacity to deliver a certain proportion of this flow dependent upon the height of buildings in the district to be protected. In the larger cities where one-half the buildings are four stories or higher, the pumper capacity should be equivalent to 30 per cent of the total fire flow.

The actual operation of an engine company, equipped with a pumper, in getting into action at a fire should be as follows, when available hydrant pressures are above 50 pounds. Assuming that the pumper is equipped with a large chemical tank or a water tank with a booster pump and that this company is the first-due to arrive, a 2½-inch line is connected to a 2½-inch hydrant outlet and stretched

up to the building which is on fire. If, in the judgment of the commanding officer, it is believed the fire can be handled with the chemical line, the chemical line should be stretched into the building if entrance has been made. If the fire is controlled with a chemical line, the $2\frac{1}{2}$-inch line is picked up and loaded. If the fire is of such proportions that it is held in check by the chemical line, but not completely extinguished, the $2\frac{1}{2}$-inch line is connected to a $2\frac{1}{2}$-inch connection to the chemical tank and the $2\frac{1}{2}$-inch line is charged with water which is under sufficient pressure to be delivered from the nozzle at the chemical hose. And again, if the fire is of such proportion that it cannot be held in check by the chemical line, the company pulls off several sections of $2\frac{1}{2}$-inch hose, attaches a $1\frac{1}{8}$-inch shut-off nozzle, and the commanding officer orders water turned on the line, which is advanced to the seat of the fire.

In some cities the department immediately charges the $2\frac{1}{2}$-inch line up to the pumper, where a hose shut-off is clamped on the line. This method saves considerable time in case water is needed from the large line, but in case the fire is extinguished without using the line, it necessitates draining the line and drying the $2\frac{1}{2}$-inch hose when the company returns to quarters. In cities where the pressure on the distribution system is from 30 to 50 pounds, it is customary for the pumper to lay its $2\frac{1}{2}$-inch line, pulling off several extra sections in front of the fire, and immediately return the pumper to the hydrant and connect the suction hose so that water can be delivered into the $2\frac{1}{2}$-inch line if needed. Under such conditions it will be seen that the chemical line from the large tank cannot be utilized when the pumper is stationed at the hydrant. For this reason it is desirable to have at least one-half of the engine companies responding into the high-value districts equipped with two pieces of apparatus, one a pumper, and the other, a hose wagon with a chemical tank. This arrangement not only enables the company to use the large chemical tank when needed, but also facilitates laying the lines, which is of considerable importance today on account of parking conditions and congested traffic. An added advantage is that in case of a large fire additional hose lines can be laid, as not only does the hose wagon carry 1,000 feet of hose, but the hose body on the pumper is also loaded with an equal amount.

Considerable difficulty has been encountered in cities and towns where fire departments have been accustomed to use direct hydrant hose streams when the departments were equipped with pumpers.

The commanding officers appeared in many cases to be under the mistaken impression that the pumpers were only needed in cases where it was necessary to call second- and third-alarm apparatus. As a matter of fact, many fires have gotten beyond control on account of weak hose streams taken direct from hydrants when pumpers were standing idle, not connected to the hydrant.

HARD SUCTIONS PREFERABLE

Pumpers should always be equipped with hard suctions and soft suctions should not be provided, for, if they are, they will be used. The soft suction is open to the following objections: If the hydrant to which the pumper attaches happens to be a small hydrant with high friction loss, or on a dead end of a small main, the water which can be obtained may not be sufficient to supply the pumper, and, therefore, the soft suction will collapse. Soft suction should not be used even where normal pressures are reasonably high, for in case the fire develops so that a number of good streams have to be used, the pressure on the mains is, in many instances, so depleted that the soft suction will collapse. One instance comes to mind where a main failed during a large fire when about a dozen steam fire engines were working with soft suctions. All had to shut down in order that hard suctions could be put on in order to obtain water at draft. Such delays are dangerous. The claim is made for these suctions that the pumper can be attached and brought into action more promptly than if hard suctions are used. This statement cannot be borne out by the facts as the time required to attach a hard suction to a hydrant and pumper is not the limiting fractional feature of the manoeuver of getting a stream on the fire, except, perhaps in the case of a company working on a fire which is burning on a pile of rubbish, in an open shed, or where no entrance or particular approach to the fire is required.

OPERATION OF PUMPERS

Drivers and operators of pumpers in the larger departments are instructed in their duties and the operation of the pumpers by the master mechanics of the department. In the smaller departments the manufacturer of the pumpers sold to the town sends a service engineer to the town with the pumper. This man stays until several members of the department become acquainted with the method of

operating the piece of apparatus. They have generally been selected by the chief of the department before the Underwriters' Acceptance Test is made, and are present at the test. They, therefore, become familiar with the speeds of the engine under varying operating conditions, and, in most cases, know the hose and nozzle layouts required to get the required capacities under varying pressures.

In some cities the master mechanics have placed brass plates on the side of the pumper body giving the pressures which the operator should carry when he goes into service at a fire for various lengths of hose lines with various nozzle tip sizes. The pressures designated are not so high that the men on the line will have difficulty holding it, and the pressure is raised by direction of the commanding officer if stiffer streams are needed.

The commanding officers, including company officers, as well as the operators of the pumpers should have a general knowledge of the hydraulics of fire streams. The subject is not at all difficult when once a fireman gets interested in the problems. In some of our larger departments all first-grade firemen can solve ordinary problems involving pressures, length of lines, elevations, and nozzle sizes with rapidity and efficiency. The National Board of Fire Underwriters prepared a booklet, entitled "Fire Engine Tests and Fire Stream Tables." This is commonly known in fire departments as the "Red Book," and it has been reprinted in three editions eight times since it was first published. It is available to officers of fire departments on application. It contains tables showing the friction loss in various sizes of hose when carrying various quantities of water, the discharge from nozzles under various pressures, as well as the vertical and horizontal reach of the stream. The few simple formulas which it contains can readily be memorized so that sufficiently accurate results can be worked out mentally by the firemen.

Pumpers should be utilized when opportunity presents itself to reinforce the supply of fire protection equipment. Each automatic sprinkler equipment is provided with a fire department connection so that the pumpers can deliver water directly into the system, even though the service connection to the street mains is shut off, the service pump out of commission, or the tank empty.

Most of the larger city departments have among other department rules one which requires some first-alarm company to stretch a line and connect to fire department connection of the sprinkler equipment, if one be installed. The practice as to which company should

do this is not uniform, but it is the opinion of the writer, supported by experience gained by observing the operations of many city departments, that the making of this connection should be delegated to the second company which arrives, for if this work were allotted to the first-due company, there would be a conflict of the rules in many cases as it is the duty of the first-due company to ascertain the seat of the fire and stretch in and extinguish it, irrespective of whether or not a sprinkler equipment be installed.

If the fire is not being held in check by the normal supply of the sprinkler equipment, it should be augmented immediately with the single line which has been connected to the steamer connection and an additional 2½-inch line stretched and connected to the second outlet of the steamer connection. Sprinklers ordinarily either completely extinguish or hold the fire in check; however, occasionally owing to structural changes which have been made in the building after the installation of the equipment, or due to the improper warehousing of stock, they are unable to hold the fire. In such cases considerable quantities of water may be needed and if the normal supply is inadequate, the supply should be further augmented by attaching siamese connections to each of the two outlets on the steamer connection and stretching in two additional lines of 2½- or 3-inch hose so that four lines will be available to deliver water into the equipment. Pressures on these lines may be carried as high as 200 pounds as there is bound to be considerable loss through the 4-inch pipe between the steamer connection and the 6- or 8-inch sprinkler riser.

STANDPIPES IN BUILDINGS

Many older buildings are equipped with dry, outside standpipes installed in connection with the fire escapes or concealed in the pilasters. These are equipped with a fire department connection at their base and their only method of supply is from pumpers. Two and one-half inch outlets are provided on each floor, generally near the window openings, and the standpipe ordinarily extends over the parapet at the roof and has a 2½-inch hose connection at its terminus.

These standpipes have two uses: First, if the fire be on one of the upper floors of a building, the fire company can take up one 50-foot length of 2½-inch hose and attach this to the standpipe and get water on the fire in a much shorter time than would be required to raise a line from the ground: Second, considerable use has been made of such standpipes to supply hose lines directed on buildings adjacent or

across the street. More powerful streams are required for this work than for inside work and higher pressures are needed on the pumpers.

BEST USE OF AVAILABLE PUMPER CAPACITY

In the larger cities the total pumper capacity is in almost all cases adequate to combat a large fire. However, in the smaller cities and towns, a large fire taxes the capacity of the department to its utmost. For this reason the chief of the department and all of its members should know how to utilize the few pumpers which they have so that their ultimate total capacity can be secured. A knowledge of the water distribution system is of first importance so that a large pumper will not be attached to a hydrant which may be on a dead end or a small main, and, therefore, not be able to deliver the capacity of the pumper. The hydrants closest to the fire should be used, provided the safety of the apparatus is not endangered. Sufficient hose lines should be laid from each hydrant and 3-inch hose, if provided, should be utilized. Lines from pumpers at any considerable distance from the fire, that is over 200 or 300 feet, should eventually be siamesed in order to further cut down the friction loss and thus enable the pumper to deliver as nearly its rated capacity as possible. For example, if a pumper is taking suction from a hydrant with the compound gage showing 41 pounds pressure and discharging through a single $2\frac{1}{2}$-inch line 600 feet long, having $1\frac{1}{4}$-inch tip, it will be necessary to carry 241 pounds pressure on the discharge side of the pump. This is equivalent to operating the pump under 200 pounds net pressure, which has cut its capacity in two, in order to furnish a fairly effective ground stream having 60 pounds pressure through this size tip, and this would result in limiting this pumper to furnishing this single stream, provided it was a 750-gallon pumper.

If a second $2\frac{1}{2}$-inch line 600 feet long is laid from the pumper and siamesed into the nozzle, the discharge pressure required would be only 111 pounds, with the result that the pumper will be operating under a net pressure of only 70 pounds, and this will enable a second line, similar in character to the first, to be taken from the pumper, provided the second line is also siamesed.

If in the first instance a 600-foot line of 3-inch hose had been utilized, a discharge pressure of only 132 pounds would have been required, which would result in the pumper's operating under a net

pressure of 91 pounds, and a second 3-inch line could have been laid from this pumper to supply a second $1\frac{1}{4}$-inch tip.

After the fire is over, as well as during floods, the fire department is frequently called upon to dewater cellars. The pumpers should never be used for such service, as the grit in the turbid water is bound to abrase the moving parts or valves of the pumpers to such an extent that the slip will become excessive, which results in materially reducing the capacity and efficiency of the pumper. Debris can easily be drawn through the suction hose into the screens of the pump, which will become clogged or, perhaps, it may pass through the screen and produce a total failure of the pump. Each department should be equipped with an ejector which can be attached to stiff suction hose, and the ejector should be operated by a $2\frac{1}{2}$-inch line which the pumper can supply, taking suction from a nearby hydrant.

Various suggestions have been made from time to time in regard to the proper coördination of water department and fire department activities and coöperation between the personnel of these two departments. I believe that you will all agree with me in that you can perform no more useful task than to discuss the subject of fire streams with the chief and the men of your department, and assist them in working out these problems so that under all conditions they will be able to utilize the supply from the water systems which you operate, as well as their own pumpers, to the best advantage.

SAN FRANCISCO WATER SUPPLY PROGRESS[1]

By M. M. O'Shaughnessy[2]

The first of May, 1928, is one of the reddest-letter days in the whole history of the water supply of San Francisco. On that day the voters of the City approved two bond issues of vital importance; one in the amount of $24,000,000 for the completion of the Hetch Hetchy Aqueduct, the other for $41,000,000 to finance the purchase by the City of the works of the Spring Valley Water Company. The 24 Million Hetch Hetchy bonds carried; Yes, 93,396; No, 11,497; Spring Valley bonds carried; Yes, 81,377; No, 20,852.

Acquisition of the private water company's property will terminate over fifty years of intermittent negotiation toward that end. Broad-gauge civic leaders have from the beginning favored the plan. Elections held in 1910, 1915, 1921 and 1927 gave large majorities in favor of the Spring Valley Company purchase but not the two-thirds necessary to approve a bond issue. The principal lines of adverse argument were based on the fear of political interference in the management of the water business and the lack of a proper understanding of the need for thorough coördination between the Hetch Hetchy project with its sources nearly 170 miles distant, and the Spring Valley system with its reservoirs and watersheds near San Francisco and its distributing mains throughout the City.

The new Hetch Hetchy bond issue provides for the construction of the remaining links in the aqueduct from the Sierra Nevada to the point of connection with the local system.

HETCH HETCHY CONSTRUCTION PROGRAM

The Spring Valley sources are now developed almost to their dependable yield, 65 m.g.d. The consumption from this system for 1927 averaged 48.5 m.g.d., and the rate of increase for the past few

[1] Presented before the San Francisco Convention, June 12, 1928. Revised November, 1929.

[2] City Engineer, San Francisco, Calif.

years indicates that Hetch Hetchy water must be available within four years. Completion of the initial development of the Hetch Hetchy Aqueduct is therefore timed for 1932. This involves the completion of nearly 16 miles of Sierra foothill tunnels now under construction, and 28.6 miles of Coast Range tunnels and 49.7 miles of pipe lines not yet commenced.

GENERAL PLAN OF DEVELOPMENT

The Hetch Hetchy system is planned for an ultimate delivery of 400 m.g.d. to San Francisco and the adjacent territory. This, together with the local supplies, will suffice for a population of between 4,000,000 and 5,000,000 at the usual daily per capita rates of consumption in cities where water supplies are fully metered. The sources of supply lie in the high Sierra Nevada region and, by utilizing the fall of the water as it flows toward San Francisco, hydroelectric power as an adjunct to the extent of some 250,000 h.p. is capable of development.

At the commencement of active work on the system advantage was taken of the fact that the Spring Valley supply would serve all purposes for a number of years to come, and the policy was adopted of constructing at the outset the more remote units of the project which would bring in revenue as early as practicable, and thereby lighten the taxpayers' burden of interest and redemption charges on bonds. Pursuant to this policy attention was from the beginning concentrated upon work in the Sierra Nevada region, leading up to the commercial generation of the first large block of power. The O'Shaughnessy Dam at Hetch Hetchy and the Lake Eleanor Dam were constructed, forming reservoirs of 76 billion gallons total capacity. The Mountain Division of the Aqueduct, consisting of 19.9 miles of tunnels $10\frac{1}{4}$ to 14 feet in diameter was constructed, and the Moccasin Creek Power Plant of 100,000 h.p. capacity with its penstocks and forebay reservoir was built. All of these units, except the power plant itself, form parts of the reservoir and aqueduct system for water supply.

The tunnels are built for the full flow of 400 m.g.d. and the reservoirs are proportioned for a dependable yield of 200 m.g.d. for municipal water supply purposes, although, taking full advantage of flood flows and drawing the reservoirs down to lower levels than would be prudent if they were actually regulating a water supply of that magnitude, the completed aqueduct has been transmitting for

power purposes an average flow of about 480 m.g.d. almost continuously since it was put in service. The total reservoir capacity will be increased from time to time by placing an additional 86 feet of height on the O'Shaughnessy Dam and by constructing other reservoirs.

Important auxiliaries for this construction work were the Hetch Hetchy Railroad 68 miles long, and the Lower Cherry Power System, a 4000 h.p. development built primarily to furnish power for construction uses but still in use in connection with the Moccasin System.

The City now enjoys a net revenue of nearly $2,000,000 annually from power production from Hetch Hetchy at Moccasin Creek. The power is transmitted over the City's transmission line 98 miles from Moccasin Creek to Newark on San Francisco Bay to a substation of the Pacific Gas and Electric Company, and this Company acts as the City's agent in distributing the power to consumers.

The second revenue producing unit to be constructed lies in the westerly end of the Hetch Hetchy Aqueduct. The Spring Valley Water Company, in 1921, was faced with the necessity for obtaining additional aqueduct capacity to bring to San Francisco water which had been made available in Alameda County by the construction of the Calaveras Dam. To avoid duplication of facilities the City proposed that a 22-mile section of the Hetch Hetchy Transbay Aqueduct be constructed and rented to the Water Company for that purpose. This was done and the City is receiving a revenue of $250,000 annually as rental for the 21.3 miles of 60-inch pipe and the Pulgas Tunnel 1.7 miles long and 10½ feet in diameter now in use by the Company.

All of the work above described was financed from a $45,000,000 bond issue. The actual construction cost was about $42,000,000, the balance of $3,000,000 representing discount on bonds sold during the war and postwar periods of high interest rates.

WORK UNDER CONSTRUCTION

A bond issue of $10,000,000, authorized in 1924, permitted continuation of the 16-mile aqueduct westerly from Moccasin Power Plant to the San Joaquin Valley. The aqueduct tunnel of 400 m.g.d. capacity is now nearly all excavated through 15.8 miles of the Foothill country between the power plant and the San Joaquin Valley, and is still to be lined with concrete. Five shafts along the line of the

Coast Range tunnels, which will be described later, are rapidly approaching completion.

WORKS STILL TO BE CONSTRUCTED

The two divisions still to be constructed are known as the San Joaquin Pipe Line and the Coast Range tunnels. The pipe line across the San Joaquin Valley will be 47.4 miles in length and approximating 60 inches in diameter with acapacity of 60 m.g.d. For about 30 miles this pipe lie will be under a head of 500 feet. Commencement of construction on this unit will be timed so as to bring completion at approximately the date of completion of the Coast Range tunnels which, therefore, merit more detailed description than has been given above to the other units.

COAST RANGE TUNNELS

The main aqueduct in the Coast Range Division will consist of 25.12 miles of tunnel from Tesla Portal on the west slope of the San Joaquin Valley to Alameda Creek, 0.58 mile of pipe across Alameda Creek, and 3.44 miles of tunnel from there to Irvington Portal on the east slope of the Coast Range two miles from the east end of the existing Bay Crossing pipe line of the system. A pipe line 1.4 miles long and 60 inches in diameter will establish connection from Irvington Portal to the east end of the Bay Crossing pipe line already constructed. The line passes about seven miles south of the towns of Livermore and Pleasanton.

The design of the Hetch Hetchy system, as already mentioned, is based upon an ultimate supply of 400 m.g.d. to the San Francisco metropolitan area, and the 10 feet 3 inches diameter tunnels east of the San Joaquin are designed to take that entire quantity. In the Coast Range, however, a flatter grade line is necessary due to keeping head elevated and economic studies have determined the policy of driving one tunnel now of 250 m.g.d. capacity with provision for a future parallel tunnel 175 feet south. For this reason all shafts centrally located between tunnels will be of a permanent type, lined with concrete. Also, all rights of way provide for the construction of both tunnels.

So far the writer is aware, the 25.12 miles of tunnel between Tesla Portal and Alameda Creek sets a world's record for length of continuous tunnel between two portals. This length is broken into six sections by sinking five shafts along the line. The longest section

between shafts is over five miles in length. This is considerably longer than is usual in such work, but experience in the Mountain Division, where four miles of tunnel was driven from a single portal, demonstrated the economy of the use of the long sections rather than increasing the number of shafts to shorten the sections.

In April, 1927, a small crew started work in this division. This crew was increased as camp facilities were built. The work now being carried on is primarily shaft sinking. All work in this division to date has been done day-labor by City forces under direct supervision of the City Engineer.

A complete headquarters with offices, warehouse, storage yards and shops has been established at Livermore. Timber for shaft headworks, shaft timbering and other purposes is framed in a mill at this headquarters. A spur connection is made to the Southern Pacific Railroad tracks at this point.

Camps have been built at the five shafts and, as soon as financing permits, camp building will be started at the several portals.

Power is taken from the main Hetch Hetchy transmission line at Seco Substation, a 102,500- to 23,000-volt step-down substation of 6000 k.v.a. capacity. Operation of this station was commenced on November 20, 1927. Transmission lines of 23,000 volts, 24 miles in length, have been built to serve the five shaft camps, and portable equipment first used in shaft sinking is now fully replaced by electrically operated equipment. Telephone connections between Livermore headquarters, Seco Substation and the five shaft camps have also been made.

It has been necessary to repair practically all existing roads in the close vicinity of the tunnels to make them available for the needs of the construction forces. Approximately 4½ miles of new road serving the five shaft camps have been constructed and portal camps will require 4 miles more to be done in the summer of 1928.

Water for construction camp purposes is taken from streams, springs and wells in the vicinity of the aqueduct line. Fourteen miles of 2- to 4-inch pipe lines have been built to serve the camps.

Shafts are similar to those built on other divisions of the project, having three compartments, two for hoisting and one for pipes and manway. The overall dimensions (in plan) to the outside line of timber sets are: length 20 feet, width 6 feet 9 inches. Timber used is 8 inch by 8 inch and horizontal frames or "sets" are spaced at 5-foot centers.

The shaft at each location will connect at tunnel grade with a cross drift between the present and future tunnel lines. This arrangement permits the use of the shaft for construction of the second tunnel without interfering with the operation of the first tunnel. Permanent concrete lining will be constructed in all shafts.

The Indian Creek Shaft is sunk through a formation known as "fresh water gravels," which consists of clay with a small content of gravel, the particles of which are generally quite small but range up to about 6 inches in diameter. Below the depth of 25 or 30 feet this clay began to show a tendency to swell and became very difficult to hold with timber. The swelling appeared to be due to air-slacking and not plastic flow. To exclude air as early as possible, and thus

TABLE 1

Hetch Hetchy Aqueduct—Coast Range Division: Progress of shaft sinking

NAME	LOCATION	DEPTH TO TUNNEL GRADE	DEPTH SUNK TO APRIL 28, 1928
		feet	*feet*
Thomas Shaft	Thomas Gulch	302	197
Mitchell Shaft	Mitchell Ravine	755	423
Mocho Shaft	Arroyo Mocho	769	744
Valle Shaft	Arroyo Valle	321	93
*Indian Creek Shaft	Indian Creek	254	215
Total		2,401	1,672

* Lined with "Gunite" as sinking progressed.

avoid trouble from slacking, it was decided to install a reinforced gunite concrete lining, carrying this down as closely as possible behind the work of excavation. This has been done with very satisfactory results. The lining was constructed about five vertical feet at a time, with concrete posts and horizontal members replacing the timber posts and horizontal members of the timber sets, and concrete panels in the place of the timber lagging. No timber was placed in the section to be gunited. A few small masses, up to one cubic yard, fell from the sides of the excavation before guniting. Such caves were simply filled up with gunite.

Location, depth and progress of sinking of the five shafts in the Coast Range Division are shown in table 1.

Each shaft will be carried about 50 feet below tunnel grade and a rock pocket will be excavated beside the shaft to receive the tunnel muck as it is brought from the heading. This arrangement has been used at all shafts of the Hetch Hetchy Aqueduct and has been found very satisfactory, as it permits hoisting to be carried on regardless of the time of arrival of the muck trains.

With a full force of 1100 men it is hoped to have all tunnels excavated by November 1931, and completely lined with concrete by November 1932, one year thereafter.

SOME WATER WORKS CORROSION PROBLEMS[1]

By Ira D. Van Giesen[2]

Since I can add nothing to the numerous existing and well known explanations of the mechanics of corrosion, only a description of a few conditions will be set forth here under which corrosion is relatively rapid, so that such conditions can be recognized and the proper preventive or remedial measures can be taken.

Within this article the following terms will have these particular and limited meanings:

Electrolysis: Corrosion caused by stray current.
Soil corrosion: Normal corrosion of any metal in any moist soil.
Self-corrosion: The primary causative factors are inherent in the metal corroded.
Mutual corrosion: Corrosion taking place between dissimilar metals by a galvanic action.

It is to be remembered that electrolysis is caused by the leakage current from the track systems of electrical street railways; all other sources of stray current are accidental and, therefore, negligible.

In general, it is against common sense to blame corrosion on electrolysis where the damage is done a half-mile or so from any of the street railway's track systems or power supply points, when the pipe system is cast-iron, jointed with cement. It is possible to imagine conditions under which electrolysis can occur at such distances from the affecting railway system, such as interlacing networks of cast-iron water-pipes and wrought-iron, welded gas-pipes. Due to the electrical principles involved, electrolysis would occur under these conditions much less often than these construction conditions are found.

So it appears advisable to know that electrolysis can occur, or better still, is occurring, before accusing the street railway companies

[1] Presented before the California Section meeting, October 14, 1929.

[2] Electrolysis Engineer, Department of Water and Power, Los Angeles, Calif.

of doing damage to water pipes. Water-works companies lose respect by calling corrosion electrolysis under conditions impossible for electrolysis to take place. It should be remembered that electrolysis is primarily an electrical engineering problem, and street railway companies have a sufficiency of electrical engineers.

The inside surface of open, steel, equalizing, or storage tanks are a source of trouble. It appears impossible to find a protective coating that protects for longer than a year or two at the most. Usually before the tank is repainted considerable corrosion has taken place.

CORROSION IN EQUALIZING TANKS

The conditions existing within an open equalizing tank are especially severe, due to the fact that the top layer of water changes very slowly, there being but a single bottom connection. At least twice in twenty-four hours the water level in the tank rises and falls several feet, subjecting the top section of the tank to an alternative flushing and bearing action.

During the heat of the day the water is low, subjecting the north inside section to the direct rays of the sun; during the night the tank stands full. Such conditions subject the paint on the north inside surface of the tank to extreme ranges of temperature. No paint made seems to be able to withstand, for long, such conditions. The reason for the failure of the paint seems to be found in the following example.

Under the conditions just outlined, one of the equalizing tanks of the City of Los Angeles, painted with a water-emulsified asphalt paint developed severe corrosion in the upper third of the tank within one year. The upper five feet of the north inside section was in the worst condition. This is the portion subject to the added action of the direct rays of the sun. Here the paint was in a hard, checked, separated, and scaly condition, much encrusted with dead algae. The water contained copper sulphate added for algae control. The paint on the lower half of the tank was in good condition.

It was thought, at first, that the paint was broken down from the outside due to this heterogeneous encrustation. However, a microscopical examination of the paint scale with its attached encrustation, both as to its physical composition and form of structure, revealed no fact upon which could be based the conclusion that failure was due to agencies working from the surface of the paint inward. Had the failure of the coating been brought about by chemical action through

cracks or abrasions in the paint film, the disengaged areas between the film and the tank would lack the uniformity which prevails throughout in this instance. Had some outside agency found access through the paint film, and the action that resulted formed a gas, the gas would find exit along the channel already open rather than through the tough paint film. Any action from the outside would progress beneath the film in various directions and open up areas of irregular shape, and not as shown in the areas marked II-C, figure 1. In every instance, the walls of these gas pockets (distended paint film) showed an abrupt rise upward from the surface of the tank, and did not contact the tank surface at a narrow angle as they would have done if the element of action had been distributed evenly over the surface and the resultant gas collected in a dome at the point of least resistance in the paint film. Evidently the action

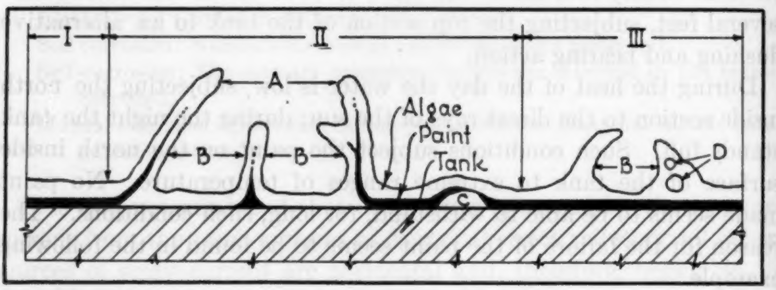


FIG. 1

was focussed directly beneath this point of formation and the gas found the least resistance directly across the paint film.

Figures 2 and 3 show at a magnification of five diameters the appearance of the top (water side) and bottom (side next to tank) respectively of the paint scales as examined.

It is apparent that the gas carried the paint film with it, and by an increase of pressure distended this film to such an extent that it became too thin and weak to impound the gas, resulting in rupture of the paint film and leaving the interior of the pockets free to the action of water and its dissolved and suspended matter. The paint film during this action must have been in a plastic state which could have existed only under two conditions, i.e., immediately after application of the paint, before it hardened, and/or, the paint film subsequently had been softened by heat.

There was nothing indicated in the scale itself to determine which of these conditions prevailed during the formation of the voids. However, since the portion subject to the direct rays of the sun was by far, in the worst condition of rupture, it is concluded that the heat from the sun acting on the enclosed air particles of the emulsified asphalt was the cause of the growth of the voids and the eventual rupture of the paint film.

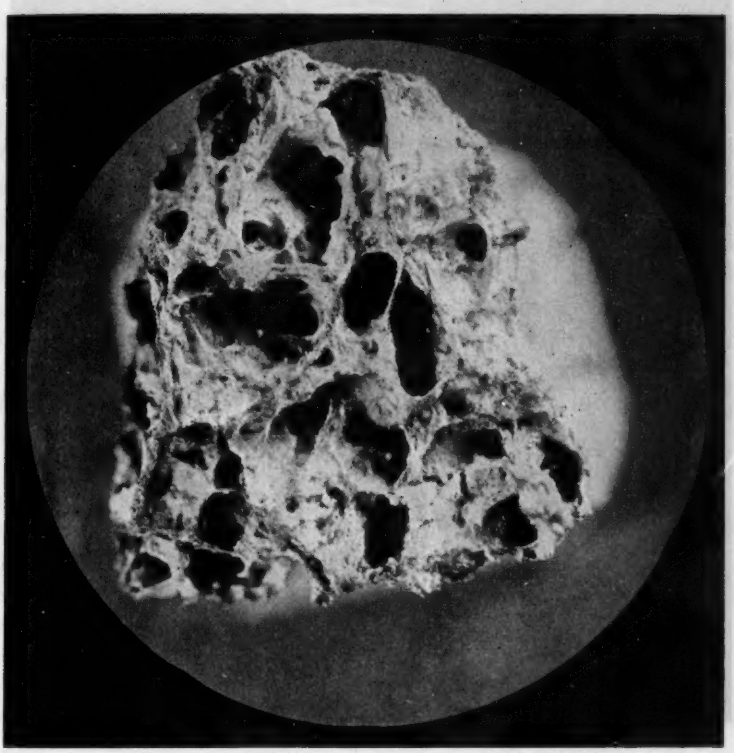


FIG. 2

The normal structure, a film of paint with a coating of algae intermingled with mineral grains, fragments of animal hairs, cotton, wood, pollen grains, insect hairs and scales, diatoms, *Fragellaria sp.*, in fact anything light enough to be carried by the winds, is shown in area I of figure 1. This stratum is loosely cemented together by being caught between the strands, or on the sticky surface of the algae.

Area III is representative of the same structure as in area I, excepting that it shows voids left by gas globules generated within the algae coating itself. The interior surface of these voids were lined with algae, and, where unbroken, present a smooth surface. There are voids of this nature that have been ruptured by the contained gas, in which case the interior is coated with debris.

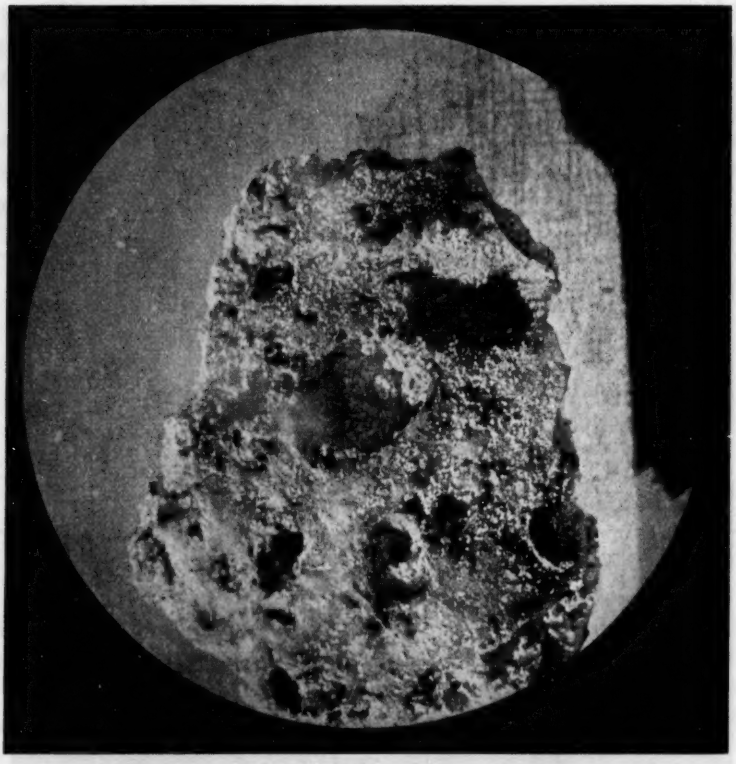


FIG. 3

The conditions presented in areas I and III are normal and had no bearing on the paint film as these conditions would prevail irrespective of the material composing the surface of the tank.

In area II, A represents a cross-section of a primary void, showing that the paint film has been lifted from the tank surface and distended until it ruptured. At B, B, are shown two secondary voids which are likewise ruptured. In tracing all these secondary voids it was

disclosed that they originally lay very close to a larger void such as A, separated by a very thin wall of paint: since the wall of A offered less resistance than the paint film proper, they followed this course of egress. The walls of these voids consisted of a gradually tapering wall of paint which was fortified on all exposed surfaces by a coating of algae, *Lyngbya sp.*, filamentous blue-green algae, forming in mats which in turn loosely held together such sediments out of the water.

At C is shown an unbroken void, or gas pocket. Voids of this character examined from the under surface of the paint film, were entirely free from outside foreign matter and showed a clean highly polished interior surface. Many of these voids contain a powdery oxidation of iron, not attached to the interior surface of the void, in the sense of being cemented, but just loosely held. On removing this deposit from the voids, the highly polished surface disclosed no marks of contact from this powder. In several instances brittle scales of oxidized iron were found adherent to the under surface of the paint film. The contact between the oxide scale and the paint film was perfect, in that there were no indications of gas pockets or voids, and the contacting paint surface after removal of the scale showed a perfect matrix of the scale and its irregularities.

From the facts in this case it would seem that the inception of the action took place primarily within the paint film itself, through the action of the sun on the air particles enclosed within the emulsified paint, and secondarily between the tank surface and the paint film due to improper cleaning leaving rust particles on the tank surface.

The remedy would appear to be found in covering the tanks and in using other than an emulsified paint unless the paint is emulsified under vacuum.

EXAMPLES OF SELF CORROSION OF PIPE

A good example of self-corrosion is found in what is generally called graphitic corrosion. A number of cases of such corrosion has been found in Los Angeles. An analysis of the conditions of each case presents some startling similarities and differences. In four cases coming to notice within the past year and a half, the cast iron of the pipe could be called poor, both as to chemical mix and as to crystalline structure. In all these cases stray current was present, ranging from a maximum of about 7 milliamperes per square foot discharge from the corroding pipe, to a fraction of a milliampere alternatively

pick-up and discharge. In the case presented herewith, which is considered typical, the electrolysis conditions are shown in figure 4. This pipe was a 6-inch cast iron, water pipe in service about 16 years.

The crystalline structure of this pipe is shown in figure 5, which is a cross-section at 11 diameters, polished and etched, and shows the variation of graphite, the internal chilled area, the central unaltered area, and outer corroded area.

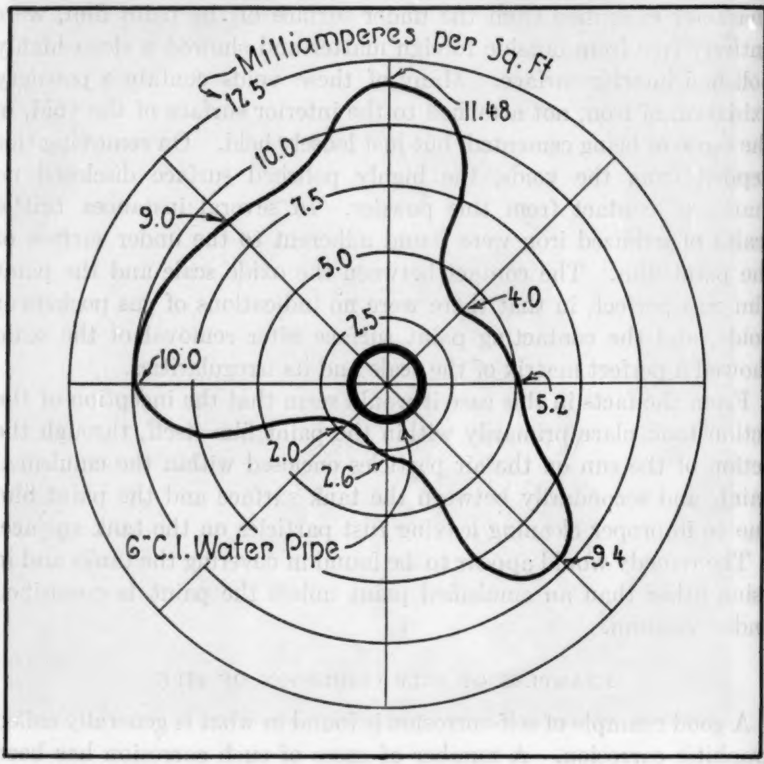


FIG. 4

Figure 6 is a section of the corroded pipe, and shows the extent of the action. Failure occurred at the right end of the section shown. Figure 7 shows at 100 diameters the structure of the inner chilled area. Figure 8 shows at 100 diameters the structure of the central unaltered area, and Figure 9 shows at 100 diameters the structure of the outer corroded area.

Following the action from the outside in, the surface was black, then occurred a layer of yellow, then a layer of brown, and finely the

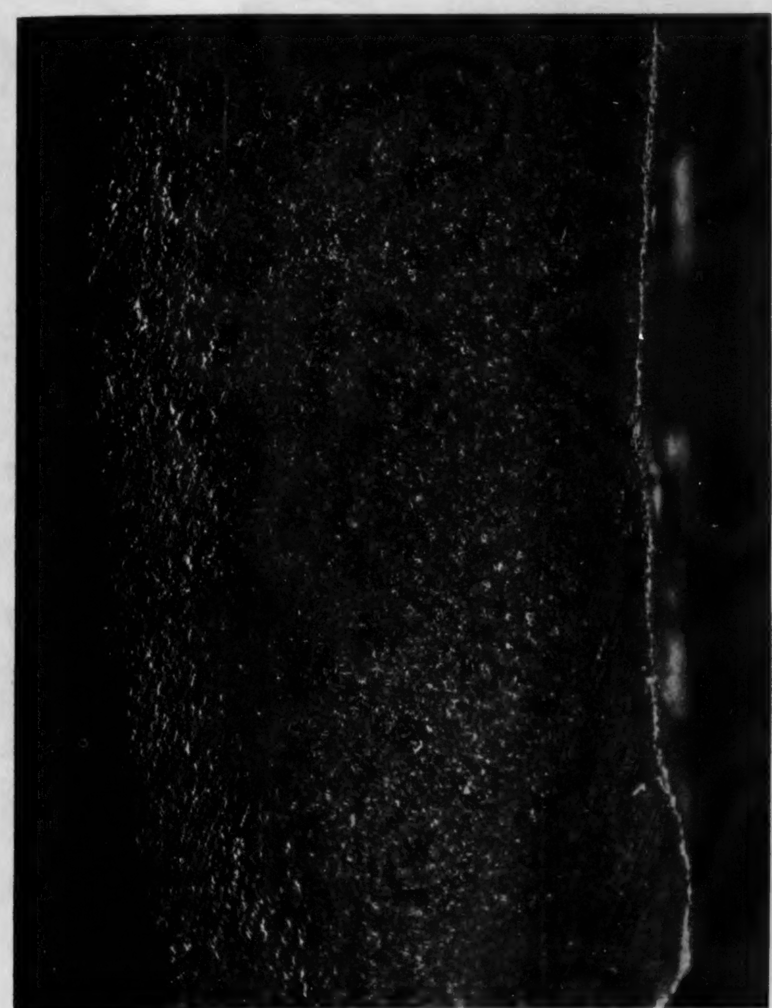


FIG. 5

unaltered iron. The chemical analyses of these areas showed the percentage results tabulated in table 1 in the order given above.

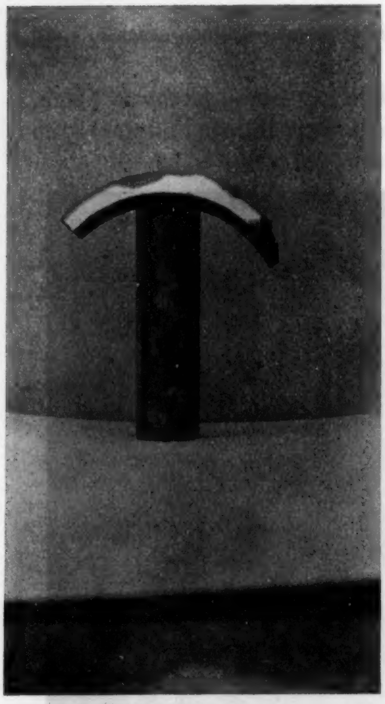


FIG. 6

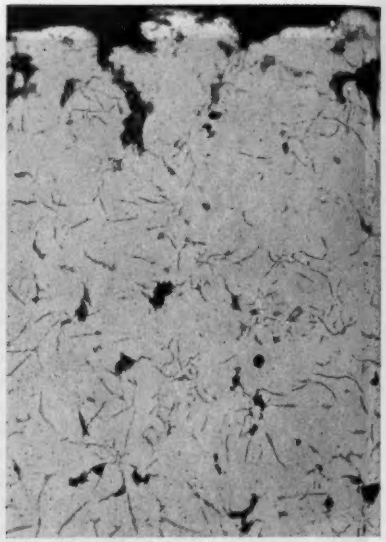


FIG. 7

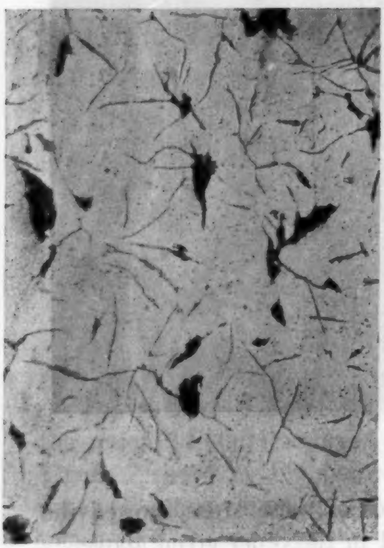


FIG. 8

FIG. 9

These compositions, structure, and progressive graphitization are typical of all the cases observed.

The one great difference observed was in the soil which ranged from a pH value of 4.3 to 8, i.e., an acidity equivalent to a 43 percent solution of hydrochloric acid to an alkalinity of a 33 percent solution of sodium hydroxide. However, as far as the action of the iron in entering solution, especially under the effect of stray current, this difference disappears and becomes a similarity, that is, the soil is always highly ionized.

Therefore, it would appear that the process of graphitic corrosion calls for an internally stressed cast-iron in which the combined carbon has a tendency to precipitate out of the solid solution as graphite, and the presence of a highly ionized soil. The primary cause is inherent in the cast iron, and the soil is a secondary factor. The remedy, then, would be a protective coating applied to the surface

TABLE 1

Percent of constituents

	CORRODED	YELLOW	BROWN	UNALTERED
Silicon (Si)	7.07	6.97	2.04	1.73
Manganese (Mn)	0.51	0.45	0.38	0.37
Phosphorus (P)	2.22	2.04	0.97	0.83
Sulphur (S)	0.023	0.018	0.061	0.060
Combined carbon	0.32	0.09	0.52	0.65
Graphitic carbon	11.28	9.15	3.68	2.40

of the cast iron to insulate it from the soil moisture. This would be efficient only as long as the coating was intact. Better cast-iron is probably a better solution.

CORROSION OF APPURTENANCES ON SERVICES

The corrosion of the U-bolts on clamped lateral or service connections is an example of mutual corrosion often thought to be electrolysis on account of the bright, clean pitted appearance of the corroded surface. Figure 10 shows the relation of the involved factors; the clamp usually being cast iron, the pipe cast iron, the U-bolt wrought iron, and the gasket some fiber composition. Corrosion occurs at the points marked A, B, C, and D, usually being worse at B, where failure often occurs. The cause is a galvanic action between the different types of iron alloys, the more worked-on wrought iron being positive to the cast iron. The iron of the U-bolt, therefore,

goes into solution to carry the generated current, or, to state it more accurately, creates the current that tends to neutralize the difference in solution pressure.

This corrosion could be reduced to a minimum by using a wrought iron clamp, a lead gasket, and polishing all contacting surfaces before

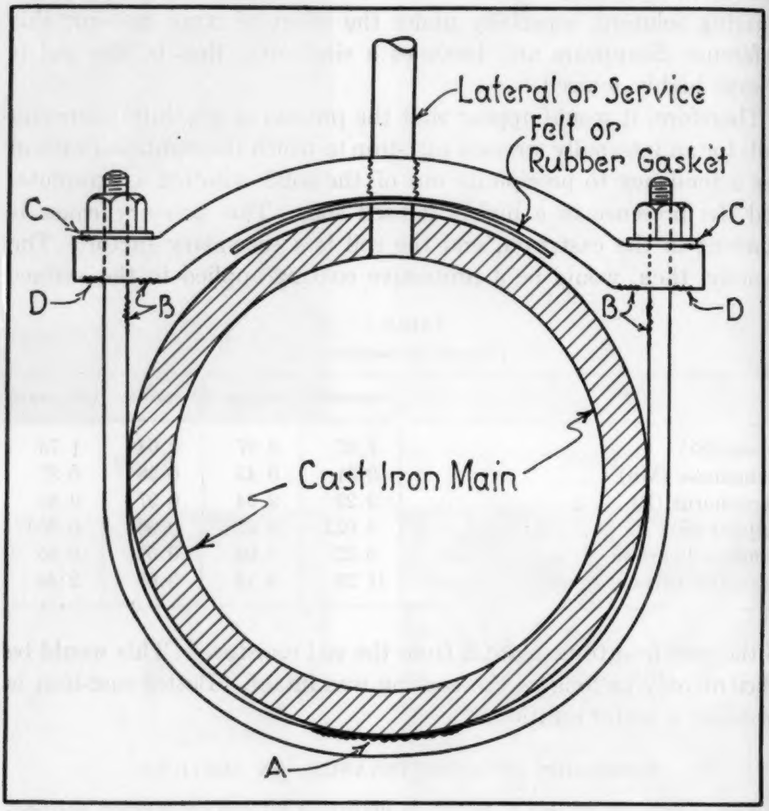


FIG. 10

connecting. After the connection is made the U-bolt should be welded at a spot or two to the clamp and to the cast iron water pipe.

Another common example of mutual corrosion is to be found in cast iron water services where a galvanized wrought iron riser is used. Figure 11 shows the relation of the factors involved and the usual locations of the corrosion at points A and B. Under these

conditions a primary cell is formed between the zinc on the riser and the adjacent iron of both the riser itself (after the galvanizing has been punctured) and the fittings. Zinc is positive to iron and under the top-soil conditions soon goes into solution forming salts which are capable of continuing the corrosion of the iron of the riser and fittings.

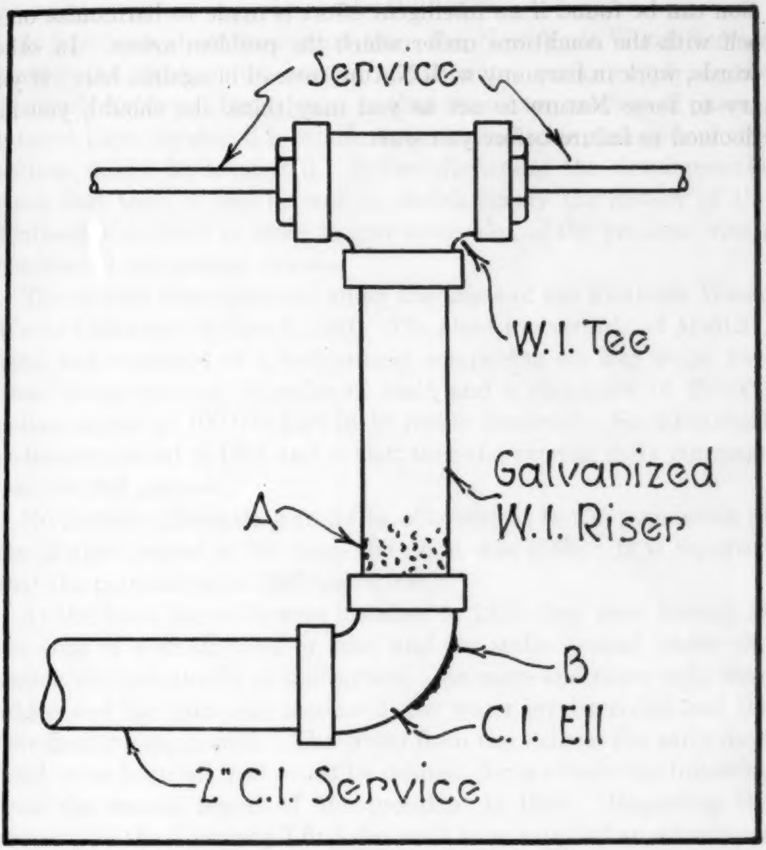


FIG. 11

The remedy is not to use a galvanized riser. Use cast iron riser and fittings to the small service connections, and black iron in the small services to the meters. In case corrosion developes between the tee and the service pipes, coat both heavily with asphaltum for two or three feet in all three directions.

To prevent mutual corrosion always use the same metal throughout a given construction. If necessary to change the type of metal used, coat the pipes for several feet in both directions from the point of metal-change with asphaltum compound. It is to be remembered that, corrosively, wrought-iron and cast-iron are two different metals.

There is a satisfactory solution for every problem, and that solution can be found if an intelligent effort is made to harmonize one's self with the conditions under which the problem arises. In other words, work in harmony with Nature instead of against her. If you try to force Nature to act as you may think she should, you are doomed to failure before you start.

THE WATER SUPPLY OF FLATBUSH, NEW YORK[1]

By A. T. Ricketts[2]

It has been about two years since the New York Water Service Corporation took active control of the water works supplying the Flatbush district of Brooklyn. In that time some matters of passing interest have developed in which it was thought the members of this section might be interested. Before discussing the developments since that time, it will be well to sketch briefly the history of the Flatbush Company in order to give some idea of the problem which confronted the present owners.

The system was organized under the name of the Flatbush Water Works Company on June 9, 1881. The plant was completed April 27, 1882 and consisted of a well supply comprising six dug wells, two Dean steam pumps, 11 miles of main and a standpipe of 230,000 gallons capacity, 100 feet high by 20 feet in diameter. Six additional wells were added in 1883 and at that time the average daily pumpage was 500,000 gallons.

No definite information could be obtained as to the population of the district served at the time the plant was built. It is reported that the population in 1890 was 8,000.

At the time the wells were installed in 1881 they were located at the edge of a small pond or lake, and the static ground water elevation was practically at the surface. As more and more wells were added and the pumpage increased, the water level receded and the lake finally disappeared. The water from the wells in the early days must have been all that could be desired, for we have the following from the annual report of the president in 1885: "Regarding the property of the Company I find the wells have supplied an abundance of as pure and wholesome water as ever entered the lips of man and the water has not only proved excellent for drinking but equally satisfactory for domestic purposes."

[1] Presented before the New York Section meeting, October 25, 1929.

[2] Deputy Chief Engineer, Public Works Engineering Corporation, New York, N. Y.

The plant was gradually developed, new wells added and the pumping capacity increased until the present owners took the plant over at which time the daily pumpage was 18 m.g. and the estimated population served through approximately 137 miles of mains was 230,000. The area served is approximately $5\frac{3}{4}$ square miles.

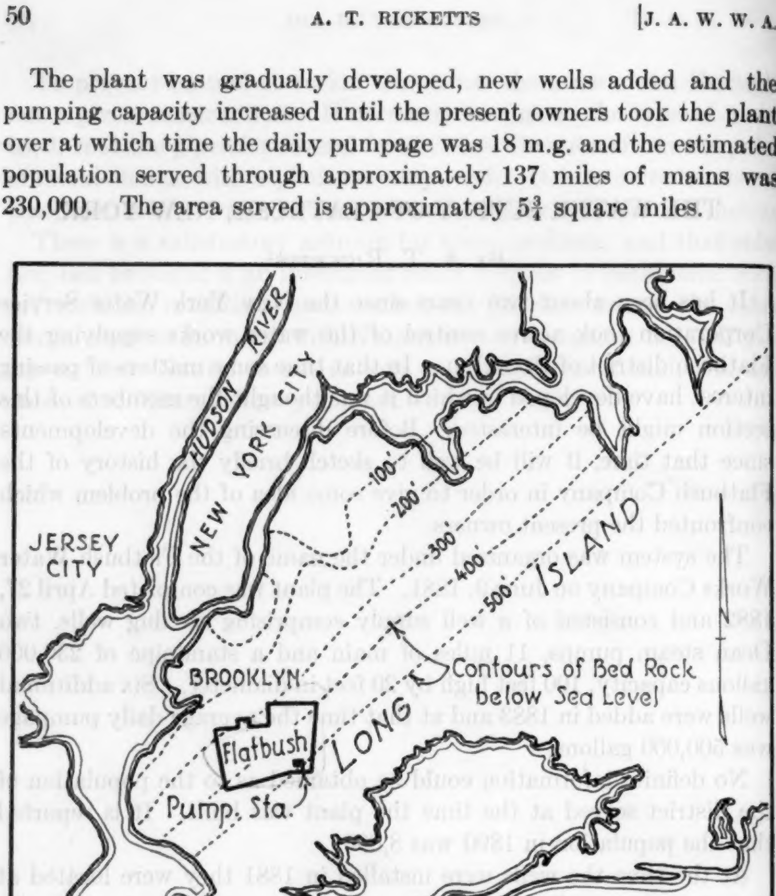


FIG. 1. APPROXIMATE BOUNDARY AND LOCATION OF PUMPING STATIONS OF WATER COMPANIES CONTROLLED BY NEW YORK WATER SERVICE COMPANY

When the property was taken over by the present owners, the problem of increasing the supply was found to be urgent. At that time a larger portion of the water furnished to the consumers was obtained from a stratum about 100 feet deep. No information was available as to the number of wells in this stratum outside of those operated by the Company. It was evident, however, that the pumpage from this source could not be increased materially. The

development of another source was, therefore, the first problem that confronted the present owners.

Figure 1 shows the location of the Flatbush District relative to the Metropolitan area. It can be seen that there was no practical way to develop a surface supply for this community. The investigation was therefore limited to the search for another ground water source. The possibilities in this direction were two, either a new well field several miles east on Long Island with long and costly supply lines, or wells in the Flatbush District driven to a deeper stratum than the one from which the present supply is mainly obtained. The former owners had driven about five deep wells ranging in depth from 200 to 325 feet, and two of these wells yielded water of unusual excellence, giving hope of favorable conditions for other similar deep wells, although the usual uncertainty existed as to what actual wells would show.

The geological formation of Long Island has been fairly well established. Figure 2 is a diagrammatic section prepared by A. C. Veatch which indicates that bed rock will be found at depths varying from 200 to 1800 feet below sea level. The surface of bed rock in the western end of the Island is shown in contours in feet below sea level on figure 1. There is some doubt about the geological formation at the immediate westerly tip of Long Island, but it is very likely that it was greatly altered at various times by the shifting of the Hudson River basin.

In spite of the difficulties and possible failure to find a suitable supply in the Flatbush district, it was thought advisable to drill test wells. The result of the test drilling indicates that it is very doubtful whether the so-called Lloyd gravel which is considered to be an excellent water-bearing material can be found in the north westerly section of the Flatbush district. Test borings in the easterly section of Flatbush were very promising and as a result, the present owners have drilled three deep wells in this vicinity to a depth of about 300 feet. The first well was developed for a yield of 2.3 m.g.d., the second well was developed for a yield of 2.6 m.g.d. and the third well for a yield of nearly 3.5 m.g.d. The chlorine content of these wells is 11, 30 and 30 p.p.m. respectively. It is hoped that the depth of the stratum into which these wells have been drilled and its porosity is such that the inflow of a soft, fresh water from the interior of the Island will continue to replenish the source and will prevent the inflow of the salt water from the ocean.

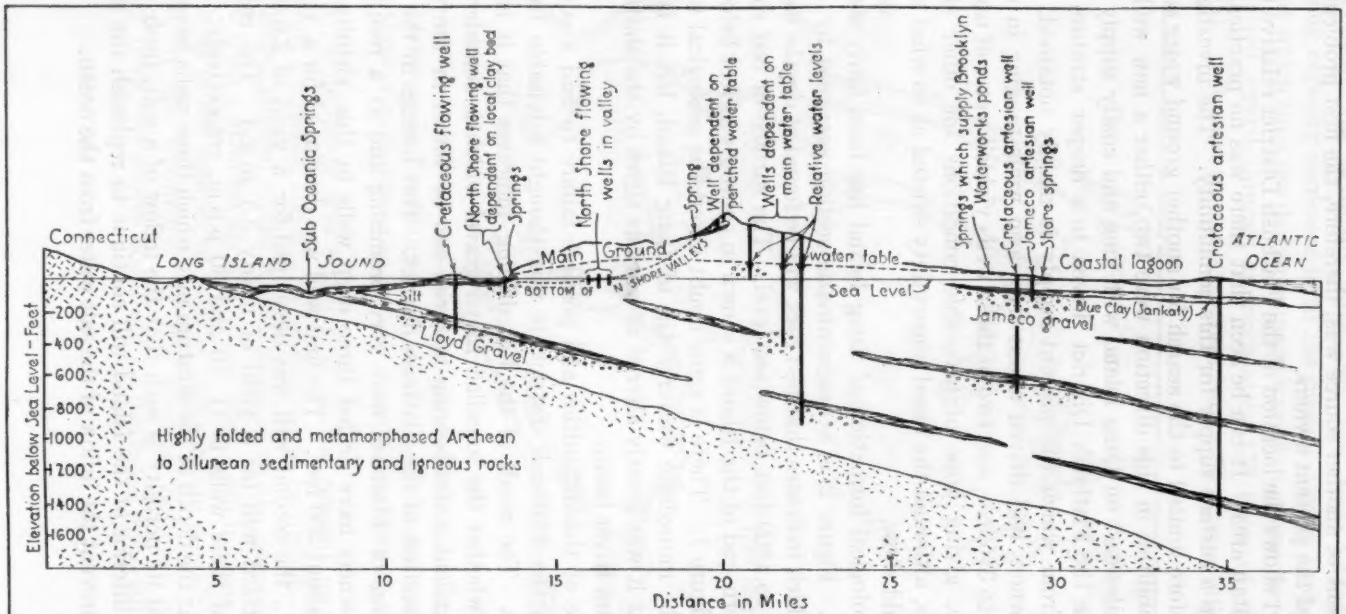


FIG. 2. DIAGRAMMATIC CROSS-SECTION OF LONG ISLAND, SHOWING GENERAL WATER CONDITIONS AND CAUSES OF FLOWING WELLS

The policy of the present owners is to continue the drilling of wells in this deeper stratum as the best and most economical means of rapidly improving the quality of the water and to meet the increased demand. In order further to improve the quality of the water throughout the system, a program has also been authorized for the installation of softening plants at some of the outlying wells where the hardness is high, but where the chlorine content is relatively low.

The type of well that the company is drilling is one known as the gravel well in which gravel is introduced in the area around the screen to form a large screening area (see figure 3). This type is well-known to most water works officials, but it may be of interest to note one or two of the problems which we encountered in the drilling of the three wells in Flatbush.

The first operation in the drilling of these wells is to bore a hole without the use of casing by revolving a cutting bit and lowering it as the material is loosened. The loosened material is brought to the surface by pumping clay "mud" down through the drill rod and forcing it up through the drilled hole. The loosened material is floated or carried out and the earth walls are held up by the stream of mud. These holes can be drilled to considerable depths and no difficulty will be experienced if the casing is placed rapidly after the drilling and in one operation. We found, however, that if the casing was lowered part way and then left for any length of time the material on the walls of the bore holes would close in and set, in most cases so hard that it was impossible to move the casing which in the Flatbush wells is 28 inches in diameter. This occurred in the first well drilled and in that case we could do very little about it, but we had learned our lesson and had resolved to place the outside casing in future wells in one operation. Our good intention was upset, however, by the fact that one of the wells was drilled near a church and due to some difficulty with the machinery we had to continue our operations on Sunday morning. The congregation objected, however, and we were forced to discontinue the placing of the casing after which it was impossible to move it. Our only alternative was to continue to the lower depth with a reduced size.

The experience in Flatbush has indicated that the outside casing should be carried down to the elevation where it is intended to place the top of the screen. It is possible to develop a well without carrying the outside casing to this depth, but at times the bored hole will cave and considerable difficulty will be experienced in getting the gravel in the proper location.

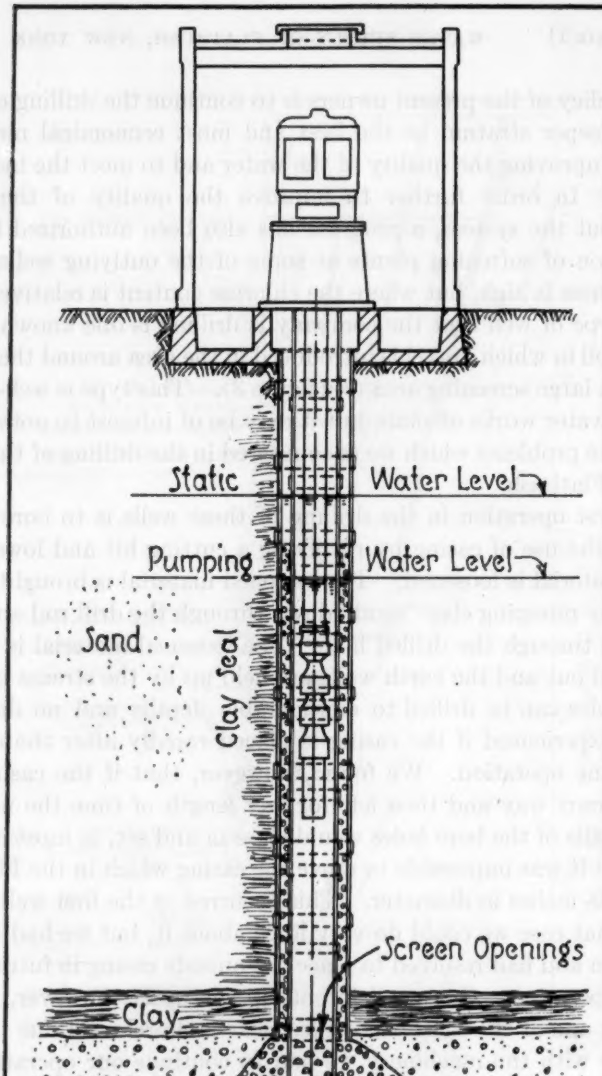

Static
Water Level
Pumping
Water Level
Sand
Clay Seal
Screen Openings
Clay
Sand &
Gravel
Gravel
Filling
Cement Plug

FIG. 3

The one other detail in the construction of these wells which is of interest is the proof that the clay mud which is used as previously described does not penetrate very far into the water bearing material even though it may be under a hydrostatic head. This was shown in the Flatbush work where one of the new wells was drilled about 75 feet from an old well of shallow depth. The old well was constructed in a manner similar to those now under construction. It is about 100 feet deep and yields about 1000 g.p.m. It was pumped continuously during the operation of the drilling of the new well without the slightest turbidity showing and without any interference in the water level.

No doubt many of you have had experiences in fishing tools and pipe out of deep wells. The speaker had his first experience in the Flatbush work of recovering a piece of equipment as large as a 14 inch deep well turbine with about 60 feet of pump column attached. This piece of equipment was dropped in one of the wells by slipping of the clamps and the superintendent of the well drilling company had a tool made with sharp dogs which would just fit inside of the pump column. This was lowered in the well and after one attempt failed, the pump was hooked. A steel line was run through a snatch block at the bottom of the drilling tower and thence out to a second snatch block fastened to a column of the elevated railway structure which was located in front of the well lot. Two trucks were hitched to the line and the pump was snaked out of the well in a very short time. The points of the dogs on the fishing tool had gouged into the pump column only a small fraction of an inch, but the tool held the load which weighed in the neighborhood of 6000 pounds even during a sudden jolt caused by the breaking of a hook on one of the trucks. Everybody was much relieved when the clamps were put on the pump column.

In addition to the drilling of new wells to increase the available supply, it has been decided to improve the service by the installation of a $1\frac{1}{4}$ million elevated tank to take care of the peak draught. This tank will be located in the most congested area which is very near the center of the water district.

The design of this tank, as shown in figure 4, is somewhat unique as it is a combination of a flat bottom tank and the ordinary curved bottom type. The bottom of the tank will be supported by radial beams between which the tank plates will be shaped in the form of a half cone; the apex lying towards the center of the tank. In order

to insure all of the water being drained from the tank, if necessary, the radial beams are sloped upward from the center enough to make the trough formed by the cone slope towards the center. A riser

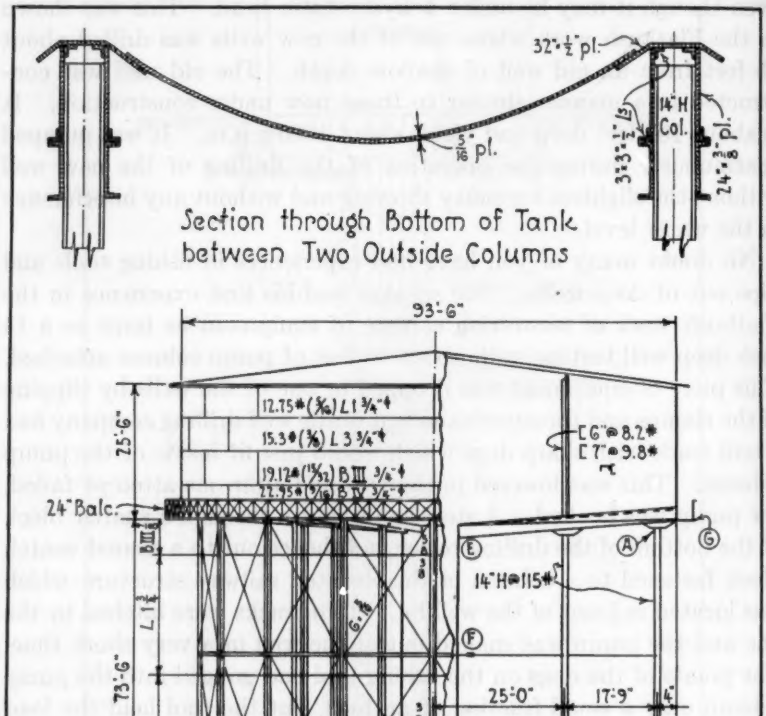


Fig. 4

pipe having a diameter of ten feet is provided and serves as a column for the inside end of the beams.

This design resulted from the requirements that the $1\frac{1}{4}$ million

storage should be contained within a 20 foot depth, in order not to vary the pressure materially between the high and low tank level. It was made by one of the well known tank companies who have applied for patents. It may be too soon to predict that this design will always result in a cheaper tank. In the bids received for the Flatbush structure, it resulted in a saving of over 30 percent as compared with the cost of the tanks of usual design.

This $1\frac{1}{4}$ million storage will take care of the peak draughts at present and very materially reduce fluctuation in pressure, not only because of the stored water but because of its strategic location. It is also hoped that due to the storage the reduced pumping rate during periods of peak draught will result in improving the quality of the water.

It is intended at a later date when the time is propitious to construct a second tank similar to the one now under contract in the western part of the district where it seems more difficult to secure the deep wells of larger capacity.

In conclusion the present owners have adopted a program for improvements in the Flatbush supply which will not only provide as speedily as possible a sufficient quantity of satisfactory water but includes the treatment of the structures architecturally in keeping with their purpose.

THE PRESENT STATE OF APPARATUS FOR HYDROGEN ION MEASUREMENTS[1]

By Crandall Z. Rosecrans[2]

Numerous papers have appeared setting forth the use of hydrogen ion apparatus in connection with water treatment or the use of water of various industries. Parker and Baylis[3] have given a summary of hydrogen ion measurements as applied to potable waters. In general, it appears that hydrogen ion measurements are essential in a water purification plant, bothfor control of the factors affecting precipitation, and to secure a final product possessing the most desirable characteristics.

Parker[4] has described the apparatus used in experimental installations, and has shown records made during automatic control of the liming process. Control of acid treatment of zeolite-softened water has likewise been accomplished by the use of the quinhydrone electrode and a recorder-controller.

It is the purpose of this paper to point out the various hydrogen ion electrodes available for use with water, and to state their characteristics and limitations very definitely. There are two possibilities in the pH measurement problem; first, measurements made intermittently by a plant chemist or operator, for control purposes, and second, continuous measurements of pH made by the use of a continuous recorder and an electrode in a flow channel. Automatic control of water treatment is a natural consequence of the second of these types of measurement. It is always well, however, to determine the exact nature of the pH measurement problem by intermittent measurements on small samples of water, before attempting

[1] Presented before the Boiler Feed Water Studies Committee Session, the Toronto Convention, June 25, 1929.

[2] Development Department, Leeds and Northrup Company, Philadelphia, Pa.

[3] Parker and Baylis, J. Am. Water Works Assoc., *15*, 22 (1926).

[4] Parker, Ind. Eng. Chem., *19*, 660 (1927).

to apply automatic recording and control to the plant. It is strongly recommended, therefore, that the water works chemist or operator make free use of the dip type electrodes for pH measurements and become thoroughly familiar with the particular pH problem in his own plant. If it is found that continuous recording of pH is desirable, or automatic control is feasible, the use of electrode flow-channels and recorder-controllers is then in order.

DIP TYPE ELECTRODES

Numerous electrodes have been used for pH measurements, and the theory has been completely outlined by Clark.[5] The hydrogen electrode is accepted as the standard for pH measurements and is useful over the entire range from pH 0 to 14. Results obtained with this electrode are entirely satisfactory. Rather careful experimental technique is necessary, however, and the necessity for a supply of hydrogen under pressure renders this electrode somewhat less desirable for plant control measurements than some other types. The platinum electrode used must be replatinized at frequent intervals; the point type, for example, should be replatinized after every determination. This electrode will give satisfactory results at all temperatures between 32° and 212°F. on water, provided that the proper temperature corrections are applied, as determined by the characteristic equation for the electrode.

The tungsten electrode[6] has been used with flowing solutions, but numerous difficulties have been encountered with it. Considering it as a dip type electrode for intermittent measurements, it is rather unsatisfactory because of the time required for it to come to equilibrium when placed in the solution to be measured. Large errors in readings are also encountered when the electrode is transferred from an acid to an alkaline solution. The tungsten electrode covers the range pH 5 to 12, and under the best conditions an accuracy of ±0.05 pH can be obtained. A pronounced drift of calibration occurs when the electrode is left in a solution continuously. This drift amounts to at least 0.1 pH per twenty-four hours. Consequently the tungsten electrode is not recommended for general use. It may be that the electrode will be developed to a satisfactory point, particularly in view of the large amount of research work now going on in connection with metal and metal-oxide electrodes. At present, how-

[5] Clark, "The Determination of Hydrogen Ions," (1928).
[6] Parker, Ind. Eng. Chem., *17*, 637, (1925).

ever, it has been the experience of the organization with which the author is associated that the tungsten electrode is not satisfactory for general use.

The quinhydrone electrode[7] within its range, is the most suitable electrode for plant control use that has yet been devised. It is capable of yielding results accurate to ±0.05 pH or better over the range pH 0, to 8.5, with solutions ranging in temperature from 45°F. up. The electrode itself is a simple gold helix or plate, and quin-

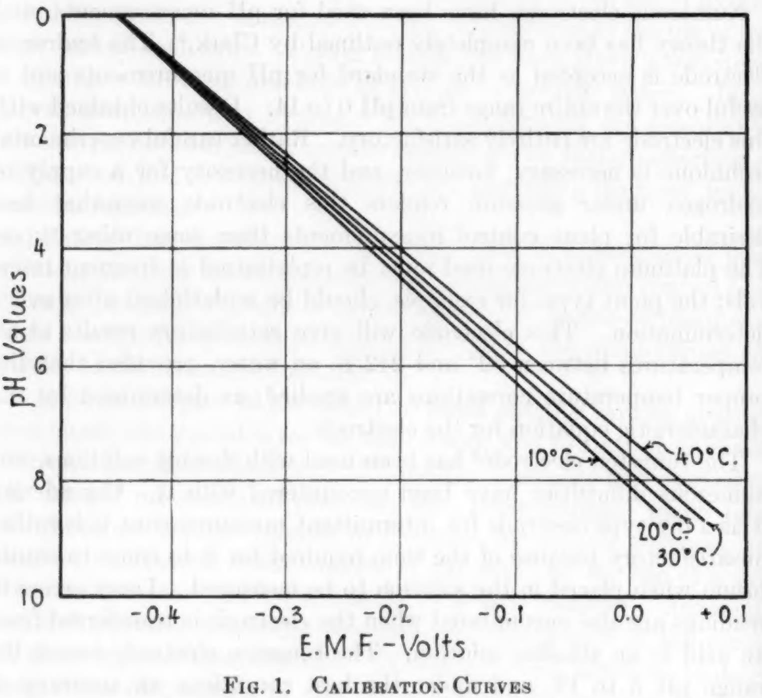


Fig. 1. Calibration Curves

hydrone, a well known organic compound, is stirred into the solution to be measured. The dissociation equilibrium of the quinhydrone in solution renders the gold electrode responsive to changes of pH. For some time it was thought that the reason for the failure of the electrode at low temperatures was the fact that not enough quinhydrone dissolved to give the proper equilibrium at the electrode.

[7] Biilmann, Trans. Faraday Soc., *19*, 676 (1924); also LaMer and Baker, J. Am. Chem. Soc., *44*, 1954 (1922).

Recent experiments have demonstrated, however, that an ample amount of quinhydrone *does* dissolve, even at the low temperature, but that the rate of solution is so low that it is difficult to get enough dissolved. This is particularly true in the case of the flowing solutions. Consequently, the correct reading is not reached unless time is allowed for the proper solution of the quinhydrone. At temperatures above about 90°F., the solution dissolves quinhydrone so rapidly that, for flowing solutions at least, the cost of supplying

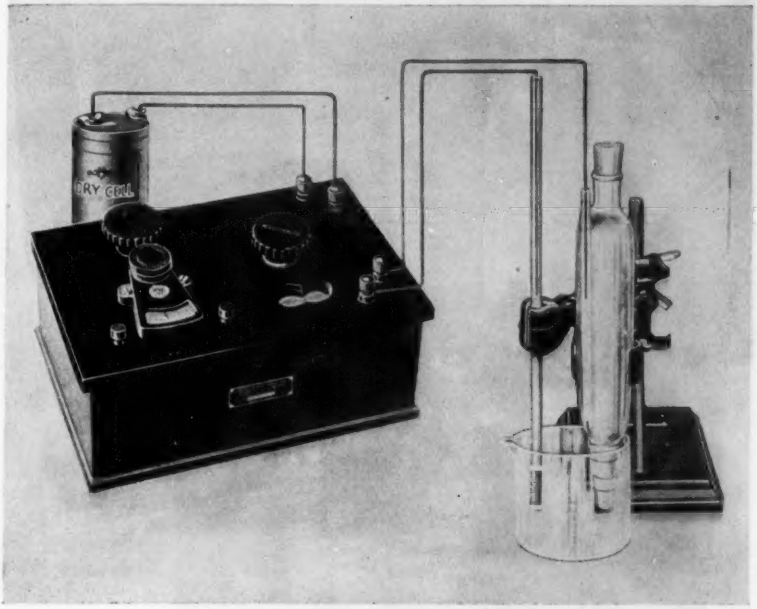


FIG. 2

the compound is excessive. The accuracy of the electrode is satisfactory, however, at temperatures up to about 180°F. It is desirable in taking readings with the quinhydrone electrode, therefore, to bring the solution to a temperature of about 65°F. To attain the highest accuracy the solution and the calomel half-cell should both be at the same temperature.

Figure 1 shows the calibration curves for the quinhydrone electrode combined with the saturated calomel half-cell. The change of reading (for a constant pH) as the solution temperature changes is

evident. This electrode will come to equilibrium and give a correct reading within two or three minutes of placing it in the solution. Its calibration is very stable, and results obtained are reliable to at least ±0.05 pH if the proper operating procedure has been followed.

FIG. 3

Figure 2 shows a small potentiometer designed especially for the quinhydrone electrode, with a calomel half-cell and the electrode itself. This device is a very satisfactory and inexpensive apparatus for determinations within the range of the quinhydrone electrode, and it is recommended for general laboratory and plant use, particularly for making a preliminary survey of plant operation preparatory to the

installation of automatic recording or controlling equipment. Figure 3 shows a portable acidity meter of somewhat higher accuracy. This instrument has two scales, one reading directly in pH for use with the hydrogen electrode, the other reading from 0 to 1.6 volts, for use with the quinhydrone or any other electrode.

Another convenient form of pH measuring instrument is the "H-ion Field Kit" shown in figure 4. It is a self contained apparatus, with all necessary chemicals, batteries, electrodes, vessels, and a small

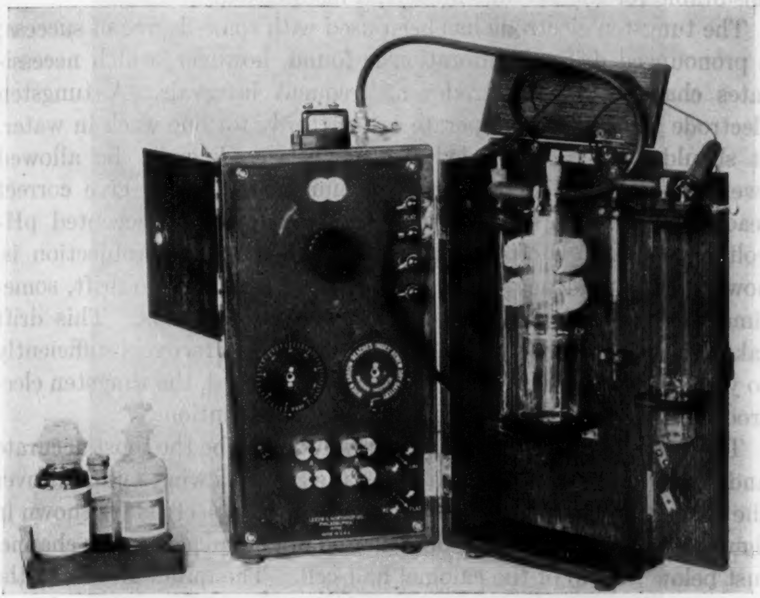


FIG. 4

tank of hydrogen. It is direct reading in pH, both for the hydrogen and the quinhydrone electrodes.

It should be borne in mind that in the problem of pH measurement, the electrodes are all-important. The problem of obtaining satisfactory electrical measuring instruments for the electrode is easy. In attempting to utilize electrometric apparatus, particularly for automatic recording or controlling, preliminary work with dip type electrodes as described above is invaluable. After the problem of securing the most satisfactory electrode has been solved, the application of automatic recording or controlling equipment to the proper electrode can be accomplished without difficulty.

FLOW TYPE ELECTRODES

Much experience has demonstrated the commercial limitations of flow types of hydrogen ion electrodes, including the air electrode,[8] the tungsten electrodes,[9] and the quinhydrone electrode.[10] The air electrode was found to be quickly "poisoned" by oil and other substances commonly found in boiler feed water. Other difficulties, such as the platinizing of the electrodes, renewal of the calomel half-cell used at that time, and the use of a filter, rendered this electrode unsuitable for the average industrial installation.

The tungsten electrode has been used with some degree of success; a pronounced drift of calibration is found, however, which necessitates changing the electrodes at frequent intervals. A tungsten electrode will ordinarily operate satisfactorily for one week in water. It should then be discarded. A new electrode must be allowed twenty-four hours to reach equilibrium before it will give correct readings, and even then, large deviations from the accepted pH-voltage curves are often noticed. The most serious objection is, however, the tendency of the voltage for a given pH to drift, sometimes as much as 0.5 pH units in twenty-four hours. This drift takes place continuously, and the electrode never recovers sufficiently to yield the proper reading. As previously stated, the tungsten electrode is not recommended for use in flowing solutions.

The quinhydrone electrode has been found to be the most accurate and convenient device for measuring the pH of flowing solutions over the range pH 0 to 8.5. A flow channel for this electrode is shown in figure 5. The actual electrode is a band of gold placed in the channel just below the tip of the calomel half-cell. The quinhydrone, in the form of pellets weighing 1 gram each, is inserted in a glass adapter fitting on the bottom of the flow channel. The test solution flows upward through the adapter at a rate of about 80 cc. per minute, and sufficient quinhydrone is dissolved from the pellets to permit the attainment of the proper equilibrium. The usual saturated calomel half-cell is used with this flow channel. Arrangements for heating or cooling the solution to the proper temperature are incorporated in a small wooden case which holds the flow channel.

Devices for automatic temperature compensation of the readings of the quinhydrone electrode are in process of development. These

[8] Arthur and Keeler, Power, *55*, 768, (1922).

[9] Parker, Ind. Eng. Chem., *17*, 637, (1925).

[10] Parker, Ind. Eng. Chem., *19*, 661, (1927).

devices will partially or completely eliminate the temperature errors shown in the calibration curves (figure 1).

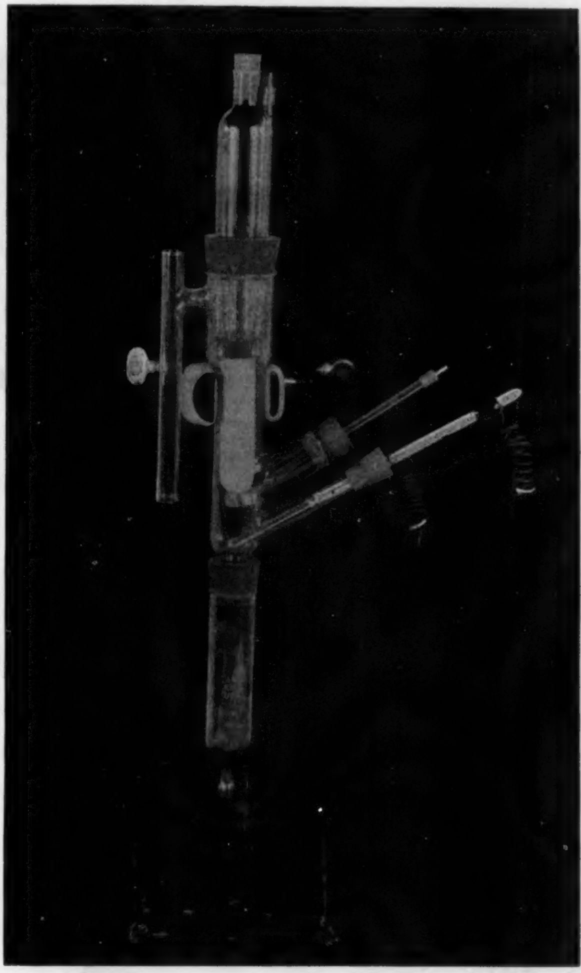


FIG. 5

An automatic recorder for use with the quinhydrone electrode and flow channel is shown in figure 6. This device records pH on a 10-inch chart, and can be arranged to actuate control valves to maintain a desired pH. Such an instrument is in service at the Dalecarlia

Filter Plant at Washington, D. C., measuring and recording the pH of the water after liming. No serious operating difficulties have been

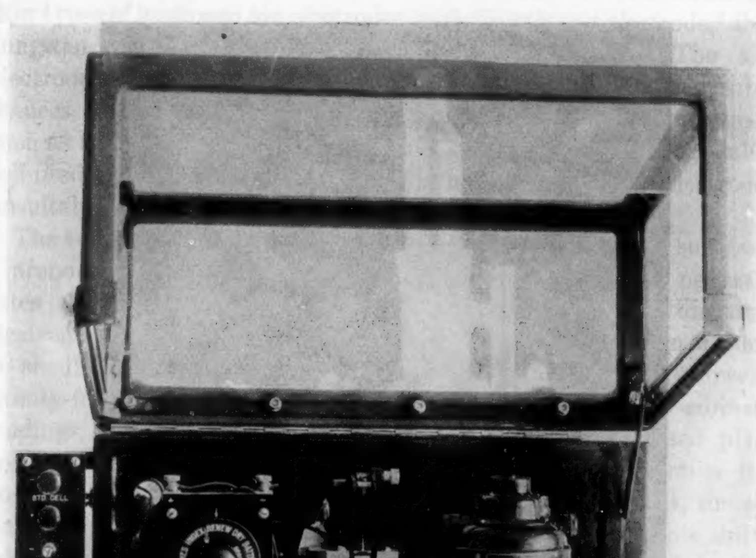


FIG. 6

encountered, and the apparatus performs satisfactorily as a recorder for pH values. The flow channel requires the addition of quin-

hydrone pellets at intervals, from two to four days, depending on the pH and the water temperature. The calomel half-cell must be flushed once a day, and saturated potassium chloride added to make up any deficiency.

In conclusion, it is strongly urged that plant chemists and operators use the dip type electrodes similar in general to that illustrated in figure 2, or some modification thereof, and that they familiarize themselves with pH measurements in general and the meaning of pH values in their own particular plants. Then if it is desirable to install automatic recording and controlling devices, the selection and operation of such equipment can proceed on a firm basis, and with definite knowledge of the characteristics of the apparatus and of the meaning of the readings.

TRENDS IN MUNICIPAL ZEOLITE WATER SOFTENING[1]

By W. J. Hughes[2] and H. B. Crane[3]

There is a growing interest in the use of zeolite in certain municipal water softening projects. This interest is following and paralleling the zeolite development in large industrial projects, where two trends appear.

One trend is to utilize the greater operating economy made possible by the more recent zeolites of increased power. The other lies in the use now possible of plant construction which in filter practice has proven its utility and suitability for the purpose.

Rapid improvements and at times rather sudden changes have taken place in the industrial use of zeolite water softening plants. These improvements and changes are illustrated in figure 1 in terms of increased capacity, higher softening rates, lower salt consumption, and reduced waste of water per regeneration.

In the early days of industrial zeolite water softeners, the comparatively poor economy of operation meant little in comparison with the enormous benefits derived from zeolite softened water. The simplicity and adaptability of the zeolite softener assisted greatly in building up a wide and popular use. This so called popularity in industry, however, could not be extended materially in municipal work because of generally higher costs than those prevailing for other methods of water softening. Structural costs also served to obstruct the adoption of the zeolite softener in place of the larger scale municipal lime—soda ash softening and filtration plant.

The principal operating cost in a chemical water softening plant is for the reagents—the lime, soda ash, alum, etc. In the zeolite softening plant, the principal operating cost is likewise for the reagent used. In this case, however, the reagent is common salt.

[1] Presented before the Water Purification Division, the Toronto Convention, June 27, 1929.

[2] Chief Mechanical Engineer, International Filter Company, Chicago, Ill.

[3] Principal Assistant Engineer, International Filter Company, Chicago, Ill.

The cost of lime and soda ash is fairly well established. Likewise the cost of salt has reached a similar position due in part at least to the greater distribution required to supply zeolite softeners among industrial and institutional users. From an average price of \$15 to \$20 per delivered ton 15 years ago, the price is now down to \$7.50 to \$10 per delivered ton.

The amounts of lime, soda ash and salt required to remove hardness from water are shown by figure 2. When these amounts are given a money value based, in round numbers, on quick lime at \$10 per ton, soda ash at \$30 and salt at \$10, the cost relationship

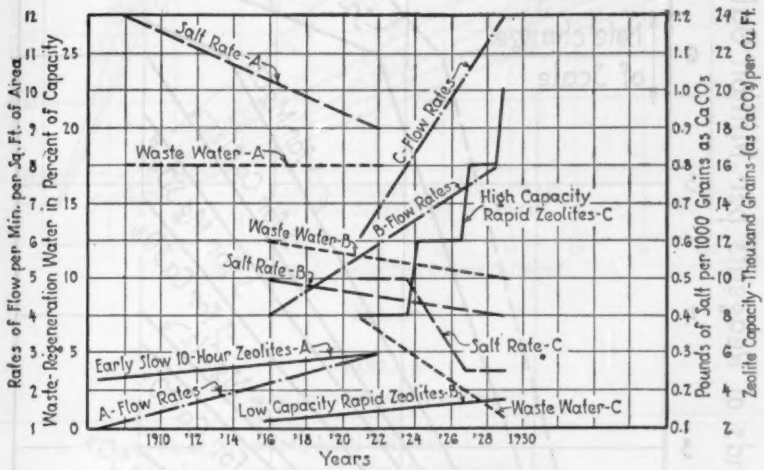


FIG. 1. PROGRESS IN ZEOLITE USES

can be shown. This is illustrated by figure 3. In the use of these charts attention is called to the fact that the salt factor relates to total hardness in terms of $CaCO_3$ equivalent. The lime and soda ash factors apply to the amounts of the various kinds of hardness substances as found.

The selection of the most economical softening method involves consideration of many factors. No one method fulfills this requirement in all cases. In a sense the selection can be competitive, based on the reagent costs which are the principal operating costs to be met. To show such a competitive selection by example, it is necessary to classify water as to condition and character. Table 1 gives a classi-

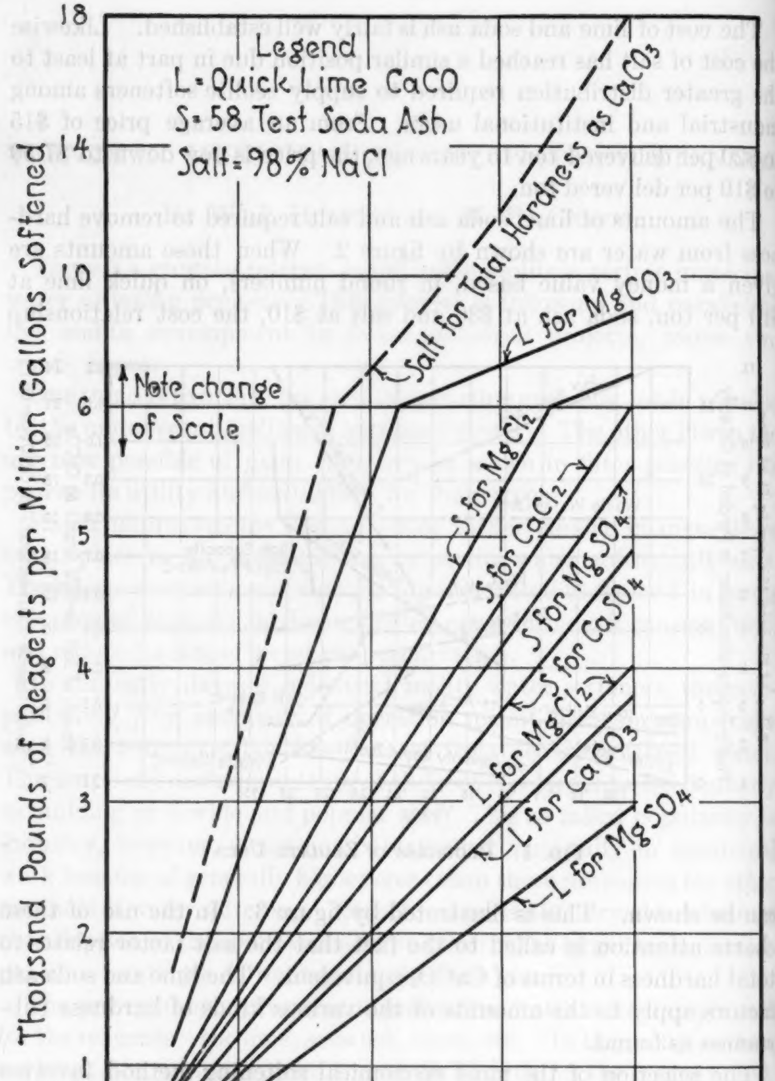

Legend
L = Quick Lime CaCO
S = 58 Test Soda Ash
Salt = 98% NaCl
Note change of Scale
Salt for Total Hardness as CaCO3
L for MgCO3
S for MgCl2
S for CaCl2
S for MgSO4
S for CaSO4
L for MgCl2
L for CaCO3
L for MgSO4
Thousand Pounds of Reagents per Million Gallons Softened
0
1
2
3
4
5
6
10
14
18
170
340
510
680
Parts per Million
10
20
30
40
Grains per U.S. Gallon

FIG. 2

fication upon which this idea of competitive selection can be built by way of example.

There are other water conditions that come outside this preliminary classification, of course, but for present purposes, those given will serve to bring out the effect of the various factors upon competitive selection. The financial values placed on the reagents required for the various divisions under class A are shown in table 2.

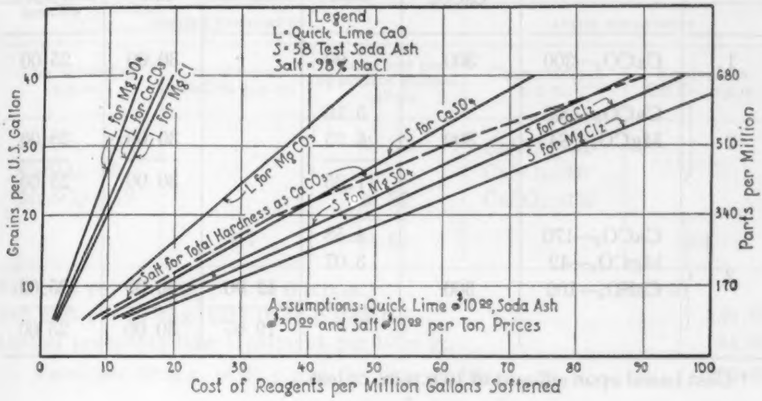


FIG. 3

TABLE 1

Classification of supply water

A. Clean, clear, iron free hard waters.
   1. Hardness, temporary, due to calcium.
   2. Hardness, temporary, due to calcium and magnesium.
   3. Hardness, both temporary and permanent.

B. All waters requiring clarification and (or) iron removal.
   1. Hardness, temporary, due to calcium.
   2. Hardness, temporary, due to calcium and magnesium.
   3. Hardness, both temporary and permanent.

The above comparison leads directly to the question of selecting a lime-soda ash plant, a straight zeolite softening plant, or a combination lime-zeolite plant. The two first mentioned may be selected for Class A waters in divisions 1 and 2 depending upon competitive reagent costs, size of requirements, etc. Class A waters of the 3rd division, as a rule, will require the combination plant for greatest economy. All waters of Class B will require either the lime-filtration

type of softening plant or the lime-filtration-zeolite combination plant. The latter is especially economical in the case of Class B waters in division 3.

TABLE 2

Comparison of reagent costs, Class A Supplies (by examples)

DIVISION	HARDNESS SUBSTANCE P.P.M.	EQUIVALENT HARDNESS, P.P.M. AS $CaCO_3$	COST PER MILLION GALLONS, DOLLARS			
			Lime	Soda ash	Salt*	Salt adjusted to 51 p.p.m., effluent
1	$CaCO_3$—300	300	7.90		30.00	25.00
2	$CaCO_3$—200		5.10			
	$MgCO_3$—84	300	6.25		30.00	25.00
			11.35		30.00	25.00
3	$CaCO_3$—170		4.58			
	$MgCO_3$—42		3.07			
	$CaSO_4$—109	300		12.00	30.00	25.00
				19.65	30.00	25.00

* Cost based upon effluent of 10 p.p.m. or less.

TABLE 3

Reagent costs for softening 10 m.g.d. to 51 p.p.m.

CHARACTERISTIC P.P.M.	EQUIVALENT HARDNESS, AS $CaCO_3$, P.P.M.	COST PER 10 M. G. SOFTENED, DOLLARS			
		Lime	Soda ash	Salt*	Salt adjusted to 51 p.p.m., effluent
$CaCO_3$—254		68.80			$\frac{366}{417} \times 450.00 = 395.00$
$CaSO_4$—86			95.00		
$MgSO_4$—119	417	25.80	150.00		
		94.60	245.00		
			339.60	450.00	395.00

* Cost based upon effluent of 10 p.p.m. or less.

Since a typical example usually serves best to illustrate a point, suppose we use the requirement of 10 m.g.d. In this example the water delivered to the mains can be 3 grains in hardness (51 p.p.m.); the water to be softened being of Class A, number 3 division, analysis as given in table 3.

In table 3, the cost of salt is adjusted to that for 10 m.g. of 51 p.p.m. hardness. In practice, the zeolite plant would not be of 10 m.g. per day capacity, but would be 366/417 of this capacity. This is a plant of about 8.75 m.g.d. output of so called zero hardness water.

TABLE 4

Result and cost of Lime-Zeolite softening applied to the same water as shown in table 3

BEFORE TREATMENT			AFTER TREATMENT	
Characteristic, p.p.m.	Equivalent $CaCO_3$, p.p.m.	Lime cost per 10 million gallons, dollars	Characteristic, p.p.m.	Equivalent $CaCO_3$, p.p.m.
$CaCO_3$—254		68.80	$CaCO_3$—51	
$CaSO_4$—86			$CaSO_4$—86	
$MgSO_4$—119		25.80	$CaSO_4$—135	
	417	94.60		214

Salt cost per 10 m.g. (214 to 0 p.p.m.)	$205.00
Salt cost per 10 m.g. (214 to 51 p.p.m.)	156.00
Cost of preceding lime treatment per 10 m.g.	94.60
Total per 10 m.g. of 51 p.p.m. by lime-zeolite	250.60

TABLE 5

Reagent costs

	COST OF 51 P.P.M. EFFLUENT	
	Per 10 m.g.	Per year
(a) By lime-soda ash method	$339.60	$124,000.00
(b) By straight zeolite method	395.00	144,175.00
(c) By lime-zeolite combination	250.60	91,500.00
Saving per year (b) over (a)		$20,175.00
Saving per year (c) over (b)		32,500.00
Saving per year (c) over (a)		42,675.00

With this output 1.25 m.g.d. of water 417 p.p.m. hardness would be mixed through a suitable bypass.

Leading now to the combination plant, table 4 shows the cost for complete lime pretreatment. It also shows the result of lime treatment and the amount of remaining hardness to be removed by the following zeolite part of the plant.

Table 5 is a summary of the cost figures shown in tables 3 and 4.

The tabulation of conservatively estimated plant costs in connection with the above summary is also enlightening. This tabulation in table 6 is based upon the output of 10 m.g.d. of softened water having not over 51 p.p.m. hardness.

A recapitulation of tables 5 and 6 shows that the differences in operating costs justify greater investment when this is required for the more expensive combination plant. This difference is increased

TABLE 6

Estimated cost of the three types of softening plants for 10 m.g.d. of 51 p.p.m. effluent

(Analysis same as table 3)

(a) Lime-soda ash plant (10 m.g.d.—417 to 51 p.p.m.)	$250,000.00
(b) Straight zeolite plant (8.75 m.g.d.—417 to 0 p.p.m.)	236,000.00
By-passing (1.25 m.g.d.—417 p.p.m.)	
Output (10.00 m.g.d.—51 p.p.m.)	236,000.00
(c) Lime-zeolite plant	
Lime treatment (10.0 m.g.d.—417 to 214 p.p.m.)	$250,000.00
Zeolite treatment (7.6 m.g.d.—214 to 0 p.p.m.)	125,000.00
By-passing (2.4 m.g.d.—214 p.p.m.)	
Output (10.0 m.g.d.—51 p.p.m.)	375,000.00

TABLE 7

Summary of tables 5 and 6

	ESTIMATED ADDED INVESTMENT	REAGENT SAVING YEARLY	SAVING IN PER CENT OF THE ADDED INVESTMENT
Lime-zeolite vs. zeolite	$125,000.00	$32,500.00	26.00
Lime-zeolite vs. lime-soda	125,000.00	42,675.00	34.05

with the by-passing of more pretreated or more raw water into the mains to increase the effluent hardness to 4, 5 or 6 grains per gallon. The greater the amount by-passed, the smaller the zeolite plant required.

The effect on investment by delivery of 4 grains (68 p.p.m.); 5 (85 p.p.m.); or 6 grains (102 p.p.m.) water into the mains instead of 3 grains water is shown by table 8.

To emphasize the economies that may be effected by recently developed construction and operating methods, it is well to refer

briefly to practices that have been followed in the past. Until recently, zeolite softeners have been operated almost entirely as pressure units. As such, they have, for the most part, admirably met the demands made on them in the industrial field. There the quantities of water to be softened are comparatively small and the possibilities for conserving head are apparent.

The pressure Zeolite softener, however, is subject to physical and mechanical limitations in connection with multi-unit operation

TABLE 8

Effect of by-passing the zeolite softening plant

CAPACITY, M.G.D.	METHOD OF TREATMENT	HARDNESS, P.P.M.	COST, DOLLARS
10.0	Lime softening	417–214	250,000.00
7.6	Zeolite	214–0	125,000.00
2.4	By-passed	214	
10.0	Output	51	375,000.00
10.0	Lime softening	417–214	250,000.00
6.8	Zeolite	214–0	115,000.00
3.2	By-passed	214	
10.0	Output	68	365,000.00
10.0	Lime softening	417–214	250,000.00
6.0	Zeolite	214–0	105,000.00
4.0	By-passed	214	
10.0	Output	85	355,000.00
10.0	Lime softening	417–214	250,000.00
5.3	Zeolite	214–0	95,000.00
4.7	By-passed	214	
10.0	Output	102	345,000.00

in softening large quantities of water. In the first place, a steel pressure vessel in its most economical form is cylindrical in shape, and provided with heads dished to a radius equal to the diameter of the tank. It is an impossibility to ship such a tank "whole" over our railroads if the diameter of the tank is in excess of ten or eleven feet. The cross sectional area of a ten foot diameter tank is approximately 78 square feet. If such a tank is operated as a horizontal softener, the operating area may be considerably increased, but the percentage

of the cross sectional area perpendicular to the longitudinal center line that can be used for the Zeolite bed is relatively small. Furthermore, it is impossible to operate deep beds in such tanks, a condition that is generally desirable where very hard waters are to be handled. Then too, each pressure tank must be equipped with a complete set of operating valves.

Such construction requires the frequent regeneration of relatively small volumes of Zeolite with the attendant opening and closing of many valves. The operating time lost on account of units out of service for regeneration is excessive and very low salt consumption is impossible. The above conditions, where very large volumes of water are concerned, have helped make Zeolite softening in pressure units uneconomical when compared with other methods of softening water giving comparable results.

A somewhat parallel condition has always existed in the operation of pressure sand filters on large volumes of water. To remedy this condition the reinforced concrete gravity filter was developed. For the same reasons, a more modern and efficient type of Zeolite softening plant has recently been successfully developed in which reinforced concrete gravity type basins are employed. Such construction satisfies the demand for increased operating areas and makes it possible to use much deeper beds. The increased volume of Zeolite under operation per unit lengthens the time between regenerations. More effective distribution of both water and brine is secured through the underdrains of a bed rectangular in shape than is possible through the underdrains of circular tanks and economy of salt consumption has been secured that has been impossible in the operation of pressure softeners. These improvements have of course made the overall operating efficiency of the concrete gravity Zeolite plant much higher than the efficiency of a pressure plant of the same capacity can be.

EXAMPLE OF MODERN INSTALLATION

The essential features of such construction are illustrated by a Zeolite softening plant put into operation some months ago for the City of Mangum, Oklahoma. It consists essentially of two reinforced concrete basins each 11 feet wide by 12 feet long and 10 feet deep containing the Zeolite, a more or less conventional pipe gallery, an operating floor, a salt storage bin or saturator and a brine measuring sump, all housed in a building, requiring a space 40 feet 6 inches long by 29 feet 9 inches wide. The Zeolite employed is Crystalite.

This plant is designed for a normal capacity of 1 m.g.d. of water in the clear well, containing not over 3 grains of hardness per gallon when handling well water, the hardness of which is 25 grains per gallon. Under such conditions the Crystalite produces 915,000 g.p.d. of water containing not over 0.5 grain hardness per gallon, to which is added 85,000 g.p.d. of the 25 grains well water, the proportioning and mixing of the two streams being controlled by an automatic proportioner as the waters enter the clear well. The operation consists of 8 operating cycles per day, each of approximately 5.5 hours "run" time followed by 30 minutes for regeneration.

A low service pump sends the water from a raw supply reservoir to the zeolite softening basins through which the water passes upwardly. The softened water is collected in steel troughs at the tops of the basins the same as wash water in filter basins, and then flows by gravity to soft water storage.

In regenerating, a nearly saturated solution of salt brine is drawn from the salt saturator into the brine mixing sump, and sufficient raw water added to dilute it to approximately 4 percent by weight, the strength at which it is applied to the exhausted Zeolite. Volumetric measurements are employed in securing proper proportions of strong and weak brine, through readings indicated on a simple depth gauge installed in the mixing sump. The brine is handled from sump to Zeolite by means of two pumps, which also supply the water used for washing out the waste products of regeneration. The pumps are served by a suction header which runs through from brine measuring sump to raw water reservoir so that suction may be taken from either direction. They are of such capacity that either one may be used for brining but both are thrown on the line for washing purposes.

No reaction or mixing chambers, coagulating or sedimentation basins are required in this plant as no solids are formed in this method of softening, as is the case where lime is applied to remove temporary hardness. Softening takes place by virtue of the Zeolite's ability to make a direct chemical exchange of its sodium base with the calcium and magnesium in the hard water.

The character of the Mangum water supply is such that it comes under Class A—Div. 3 in table 1. The water is obtained from wells, is practically free from iron, and the turbidity and suspended matter are under 3 p.p.m. Approximately 50 percent of the total hardness present is permanent hardness that would have required soda ash for removal if Zeolite had not been used.

OPERATION OF ZEOLITE SOFTENER

In considering Zeolite softening for the municipal water supply, it is important to remember that it is altogether practical to control the hardness of the water delivered the consumer. Control may be accomplished by mixing in proper amounts, Zeolite softened water with (1) hard water or (2) water that has been treated with lime. It should be borne in mind, however, that best results can probably always be obtained when sufficient reagents are employed to carry reactions as far toward completion as is possible with the apparatus available. When waters so treated are mixed, no changes take place other than an adjustment of the total hardness. No after reaction occurs.

Zeolite softening can be entirely successful only when a clean, clear water is applied, and the water stabilized if it has been given a previous lime treatment. By stabilizing we refer to the methods now successfully used in practically all modern municipal chemical water softening plants for adding CO_2 gas to the water after lime treatment.

No one has as yet been able to successfully combine the functions of filtration and softening in a Zeolite bed, nor will any one ever be able to do this as long as the nature of Zeolite remains as it is. In the first place, a screen analysis of any Zeolite that has ever been used shows that the material is not a suitable medium for correct filtration, when gauged by the standards used for determining a proper filter sand. The necessity of using some coagulant on water applied to a rapid sand filter has long been recognized and likewise the fact that without residual coagulum on top of the sand bed, simple straining is about the best that can be accomplished. All Zeolites are porous to a degree and there is without doubt a relationship existing between structure and available capacity, although this relationship is not too well understood. If then, to make the Zeolite a more effective filter medium we coagulate the water, it is reasonable to suppose that the effectiveness of the material as a water softening agent will be reduced on account of the coagulum that will penetrate the bed, adhere to the Zeolite grains and inhibit their functioning in the manner intended. Furthermore, the effective weights in water of various Zeolites are such that it is impossible to backwash them at rates high enough to remove foreign substances so deposited as is possible with filter sands. The above remarks apply equally as well to suspended matter in waters to which coagulants have not been applied.

As an indication of the accuracy of these statements, let us refer to experiences in operating Zeolites on unfiltered Chicago City water. There for a considerable portion of every year the water has turbidity probably under 3. On occasion turbidity increases to 100 p.p.m. These high readings are found to coincide with the times each year when on-shore winds persist for periods of one or two days. Persistent attempts have been made in the past to operate Zeolite softeners on unfiltered Chicago water, but all of these softeners have

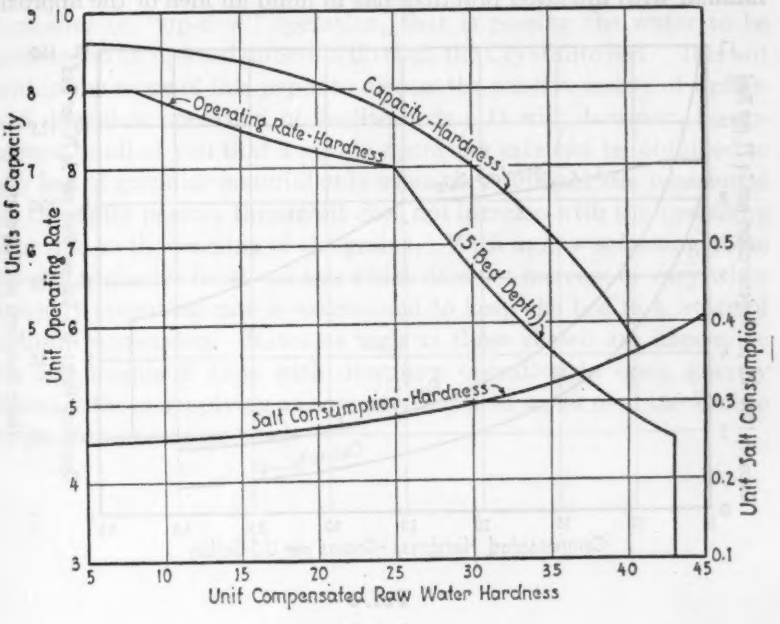


FIG. 4

eventually come to grief on account of the small amount of matter in colloidal suspension that the water contains.

The above remarks may be summarized by saying that if a water is unclean it must be properly filtered before it is softened with Zeolite.

It is conceivable even that, in a Lime-Zeolite plant such close control of the lime treatment can be maintained, and that sedimentation will be so complete that water of sufficiently low turbidity may result to make filtration an unnecessary step before Zeolite treatment. In all such cases, however, effective means must be provided for the recarbonation of the lime softened water to stabilize it and

prevent incrustation of the Zeolite. The necessity for this practice is so well understood by those versed in water softening, that further comment will not be made.

An increasing number of inquiries is being received from consulting engineers concerning Zeolite softening for large municipal water supplies. A request frequently made is for an approximate figure of the cost of a Zeolite plant per m.g. daily capacity. Such a question is a perfectly natural one and comes from the fact that any engineer familiar with filtration practices has in mind an idea of the approxi-

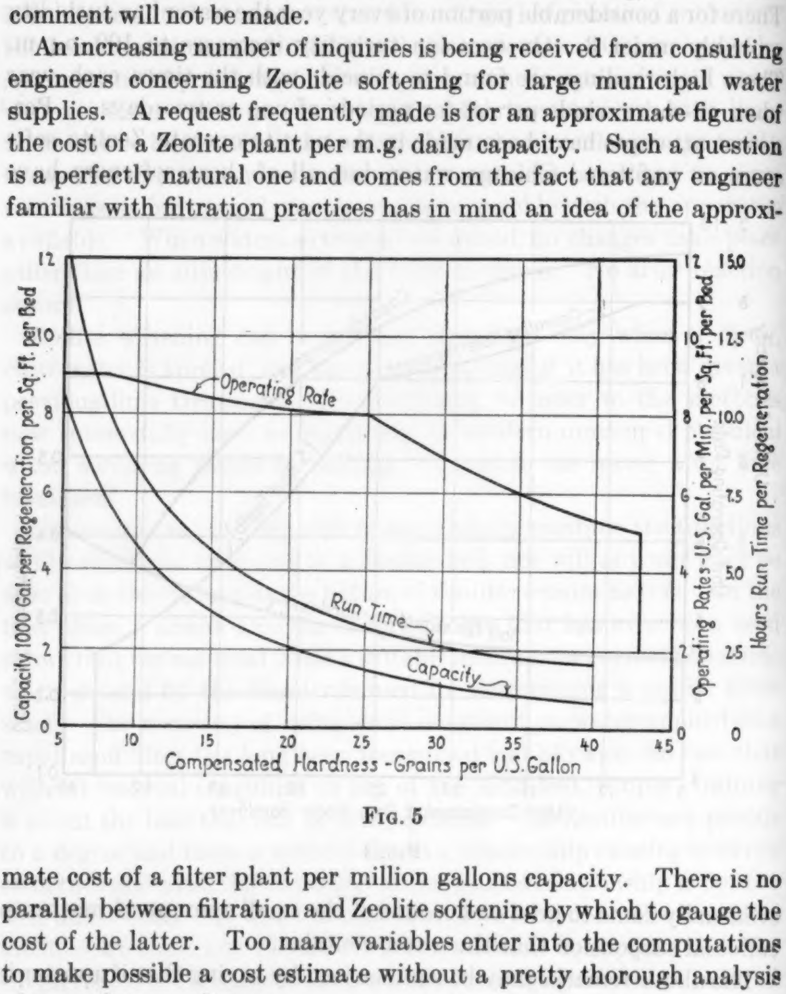


FIG. 5

mate cost of a filter plant per million gallons capacity. There is no parallel, between filtration and Zeolite softening by which to gauge the cost of the latter. Too many variables enter into the computations to make possible a cost estimate without a pretty thorough analysis of prevailing conditions.

Figure 4 shows that for International Crystalite Zeolite, under various operating conditions, the unit capacity, operating rate and salt consumption vary with the hardness of the water to be treated, the capacity and rate decreasing as hardness increases while salt consumption increases slightly with the hardness.

Figure 5 has been compiled from figure 4 and shows the per-

formance of a Crystalite bed 5 feet in depth and one square foot in operating area. With applied waters the hardness of which is 25 grains per gallon and less, operating rates in excess of 8 g.p.m. per square foot can be realized. While the curves do not show it, these rates can be maintained without interruption to the limit of total capacity of the volume of Crystalite under operation. Such high operating rates will probably surprise some of you who have in mind the limitations imposed upon the operation of sand filters. It is explained, however, by the fact that these curves represent performance on "up-flow" operation, that is passing the water to be softened in an upward direction through the Crystalite bed. It is not within the scope of this paper to discuss the relative merits of upflow and downflow operation of Zeolite beds. It will, however, be apparent to all of you that a steady operating rate can be obtained in any bed of granular material only when the frictional loss occasioned by the water passing through it does not increase with the operating time due to the packing of the grains. With upflow softening there is but a negligible frictional loss which does not increase or vary when a steady operating rate is maintained to keep the bed in a state of uniform suspension. Rates as high as those shown are impossible for any length of time with downflow operation in open gravity basins without supplying an excessive depth of water over the Zeolite to produce operating head.

CHOOSING PERSONNEL IN THE WATER BUSINESS[1]

By Carl K. Chapin[2]

The mere mention of my subject in the presence of this group of utility operators instantly conjures up in compelling array the historic struggles in the past, of the purveyors of older time, who, so we are told, resented the inalienable right of royalty to buy without the seller's consent, provisions or supplies which royalty required for its use. No willing buyer and equally willing seller in those olden days. This act of purveyance, as it was called, which royalty lorded over the possessor of necessities, has in our times been set topsy-turvy. We find the public buying many of its necessities without the powers of discretion, or refusal being invested in the seller of such supplies; as, for instance, water, for which this Association stands sponsor in public needs.

And what is still more to the point, the terms and conditions under which such traffic in sales must take place are now almost entirely dictated by the royal arm and hand of the public, a right hitherto reserved to royalty alone.

Truly might it be said that we public servants in public utilities have become servants to a new King, the Public. As for the commercial problems involved in this exchange, they are no nearer complete solution than they seem to have been in days of old. Albeit we solve some essential details only to find some new complexities challenging our attention and ability.

To outline briefly present day problems, let us first state the question as one referring to the *recurrent sales transactions of our business*, and not to be confused, in accounting classifications, with New Business and its many problems.

Regular commercial activity thus has to do mainly with opening a service account with a consumer, carrying on the sales recording and collecting end of this service, until one or the other parties to the

[1] Presented before the California Section meeting, October 22, 1929.

[2] Commercial Director, Los Angeles, Calif.

transaction, for good and sufficient reason, terminates the arrangement, and the business between the two parties is brought to a close.

THE IMPORTANCE OF PERSONNEL SELECTION

Without appearing to decry the importance of any other branch of our utility business, may I make so bold as to venture the statement that commercial activity and commercial personnel are brought into more intimate contact with the public being served, than any other part of a working utility system. The recurrent reading, billing, collecting, investigating, etcetera, which logically are a part of the commercial end of the business, bring into the forepart of any analysis the inevitable prominence that personnel must play in the success or failure of our business. This responsibility of the personnel is being given more and more attention, and we may well devote much study and effort to this phase of our commercial problems.

How do we select our personnel? How do we train and promote from time to time, this human element of the business? How do we rate or measure their efficiency and performance?

Our engineering associates have well accepted standards for selecting, testing, and maintaining physical equipment, yet we seriously doubt if the much less tangible characteristics attached to the personnel side of our business are recognized and developed to that same degree of ultimately attainable efficiency, which characterizes the physical technic we see upon every side.

Surely, I make no idle statement, when I say that one false or unfortunate move on the part of an employee can do more toward upsetting a utility's business routine, than the breaking of an important machine part in the physical system. Repair parts repose upon a handy shelf or in a warehouse awaiting their instant use in case of need. The same cannot be said regarding the sudden replacement of an uncoördinated part of a human mechanism. We spend endless time and money while breaking in and training the human element, before we even approach the perfection of experienced help. If this be true; how very important then, becomes this phase of selecting, training, and rating of personnel.

Edison with his much advertised questionnaire method of human analysis, has developed his own intelligence tests to such a point. We are led to believe he counts greatly on them. In our schools and colleges we hear of I.Q. tests. In the army we hear of the Alpha

tests. All seem to be striving to understand and analyze the human who confronts them.

It is my opinion that any intelligence grading method which falls short of helping the individual to grade himself, in addition to furnishing his employer with a record of achievement and ability, even though latent, is not well suited to general application; and any method which can be derived that *will* serve both purposes is worth using.

PERSONNEL GRADING

The method here outlined is an example of personnel grading which is equally beneficial to the rank and file of employees and to the management, which is responsible alike for their actions and their welfare.

Let us divide this examination or rating into appropriate subdivisions which assist the examiner in arriving at conclusions.

Numbers 1 to 4 inclusive are intended to reflect the quality quotient of the individual; numbers 5 to 8 inclusive, judge quantity of work and ability; while numbers 9 to 12 inclusive give the dependability rating, and 13 to 19 answer the questions of general suitability.

With each heading subject to a maximum 5 points, one asks where is the twentieth subject to give a perfect score of 100. My answer is simply that taking this subject as seriously as it deserves, one comes readily to a conviction that no perfect score is possible or necessary, whether self analysis is the operation we are interested in for the moment, or if we are to judge another.

One other point is worth raising. There is no effort here to select employees from any group or class who could not be said to be in the upper third of a general class analysis. It is apparent that if the grading were started at 70 percent on each heading that a combined rating of 70 percent throughout would give 70 percent of five times 19, or a total of 66.5, which is just below the upper third and, therefore, we desire to eliminate such individuals as being poor selections from which to train employees in our very important business.

General readings of character analysis

1. Clearness of thought and expression
2. Soundness of judgment
3. Care and competence in matters of detail
4. Cheerfulness in relation to work and public

5. Perseverance under all conditions
6. Ability to make quick decisions
7. Willingness to keep busily engaged
8. Measure of rate of change in capacity
9. Tenacity in holding to opinions once formed
10. Willingness to accept responsibility
11. Enthusiasm for one's work and future
12. Moral habits, on and off duty
13. Manners, appearance and bearing of individual
14. Initiative and aggressiveness
15. Tact and courtesy in meeting and handling others
16. Tendency to coöperate with others
17. Modesty a natural trait
18. Familiarity with general problems of our business
19. Service record and age limitations prescribed

To condense the charts and to make most apparent any extreme qualities, good or bad, the columns are arranged so that consistency or its lack are at once apparent, in that wide variations will be easily discovered in scanning the percentage columns.

CONCLUSION

Summing up the viewpoint of successful management, two essentials are realized at once when a group is analyzed. Those above the average for the group can be stimulated and encouraged with the hope of attaining hitherto impossible records in service and efficiency. While those below average can be encouraged to bring up their standings, or failing to do so, must be weeded out.

When the analysis method is used with the full knowledge and understanding of the individual there is a constant wholesome background to the effort to improve with encouragement to expect greater things. No chance is left for the discontent or unhappiness which comes with a realization that chance or favoritism are dominating factors that may surround the shifting of personnel in positions or in wage scales.

May it be ventured also that a knowing, thinking, hopeful personnel will eventually make the utility management and the public as well forget there are such things as commercial problems in the supply of water for general public use. When that time comes, lost payments that come through the mail will all be found promptly; no bad meter readings will disturb an otherwise satisfied consumer; no posting of payments to wrong accounts; no lost bills and hasty

Percent of 5 points—Total

	75–80	80–85	85–90	90–95	95–100
1. *Clearness of thought and expression*					
Highly effective thinker and talker					—
Thinks and talks clearly				—	
Variable in thought and expression			—		
Sometimes thinks clearly		—			
The muddy thinker	—				
2. *Soundness of judgment*					
A keen, sound, quick thinker					—
Alert and capable				—	
But moderate judgment			—		
Neither alert nor accurate		—			
Slow or erratic in reaching conclusions	—				
3. *Care and competence in matters of detail*					
Masters of detail					—
Good at handling detail				—	
Capable of handling detail			—		
Impatient of detail		—			
Incapable of detail	—				
4. *Cheerfulness in relation to work and public*					
Invariably cheerful					—
Habitually pleasant				—	
Ordinarily pleasant. There are too many of these. The real test is being pleasant in times of stress			—		
Sometimes gloomy		—			
Grouches	—				
5. *Perseverance under all conditions*					
Unfailingly persevering					—
Usually persevering				—	
Ordinarily persevering			—		
Sometimes discouraged		—			
The quitter	—				
6. *Ability to make quick decisions*					
Invariably makes quick decisions					—
Can make prompt decisions				—	
Avoids prompt decisions			—		
Cautious in making decisions		—			
Lacks decision	—				

Percent of 5 points—Total

75 80 85 90 95 100

7. *Ability to keep busily engaged*
   - Always reaching out for more
   - Always ahead
   - Regularly up to schedule
   - One who is occasionally caught up. Is this worse than never caught up, because management can count in the first and protect itself, while in this one it fails unexpectedly
   - One who is always behind

8. *Measure of rate of change in capacity*
   - Rapid improvement
   - Increasing improvement
   - Remains the same
   - Moderately slowing up
   - Rapidly slowing up

9. *Tenacity in holding to opinions once formed*
   - Wholly unyielding
   - Tenacity
   - There is no middle ground applicable to this characteristic. One either does or does not
   - Indecisive
   - Unstable

10. *Willingness to accept responsibility*
    - Absolutely dependable
    - Normally responsible
    - (No middle ground as in tenacity in holding to decision)
    - Avoids responsibility
    - The "Buck passer"

11. *Enthusiasm for one's work and future*
    - Contagiously enthusiastic
    - Enthusiastic
    - Variable
    - Indifferent
    - Apathetic

Percent of 5 points—Total

75 80 85 90 95 100

12. *Moral habits, on and off duty*
    - Excellent
    - Good
    - Fair
    - Poor
    - Bad

13. *Manners, appearance and bearing of individual*
    - Highly attractive
    - Congenially stimulating
    - Normally agreeable
    - Negative
    - Repellant

14. *Initiative and aggressiveness*
    - Aggressive initiation
    - Above average
    - Passive
    - Reluctant to initiate
    - Utterly lacking in initiative

15. *Tact and courtesy in meeting and handling others*
    - Highly adaptable
    - The "good mixer"
    - Normally courteous
    - Arouses occasional friction
    - Tactless and unsociable persons

16. *Tendency to coöperate with others*
    - Exceptional team worker
    - A good team worker
    - A variable coöperator
    - A poor coöperator
    - Intolerant of the ideas of others

17. *Modesty a natural trait*
    - Retiring
    - Modest
    - Variable
    - Rather talkative
    - Offensively assertive

Percent of 5 points—Total

	75–80	80–85	85–90	90–95	95–100
18. *Familiarity with general problems of our business*					
Long and varied experience and school background					—
Fair schooling and experience				—	
Fair experience			—		
No experience		—			
No primary schooling or training	—				
19. *Service record and age limitations prescribed*					
The superlative service range is from twenty to twenty-five years					—
Fifteen to twenty and from twenty-five to thirty years service				—	
Ten to fifteen and with thirty to thirty-five years service			—		
Five to ten years experience and from thirty-five to forty have an equal rating		—			
One to five years and over forty years experience are the least valuable	—				

cut offs, because of non-payments; and perhaps even no services cut off at wrong addresses; no more chance for mispelled names, bad addresses, nor saucy clerks snapping their answers over the counter and telephone. Credit ratings will be safely analyzed without unnecessary deposits; counterfeit money and N.G. checks will disappear; in fact, the millenium in commercial procedure will come, either by perfection in personnel or by finding a substitute for personnel, which is an infinitely greater problem.

COMMERCIAL PROBLEMS IN THE WATER BUSINESS[1]

By L. M. Anderson[2]

The public relations and advertising divisions have their place in the water business, but no where can friends or foes be made so readily as in the commercial division where periodical contract is necessarily had with the consumer.

The contract, as well as meter reading, collection and adjusting divisions, all have their important place in their relations with the public, who always expect the best treatment by the employees of the utility.

Every effort should be made to secure a signed contract for water service before the use begins.

One of the great difficulties which tends to produce misunderstanding and ill feeling is that many will neglect to make application before beginning the use of the service. Someone will move from the premises without ordering a shut-off and a closing bill and a new customer will begin using water with no thought of making application therefor. The meter is read, the bill rendered under the old tenant's name and no attention is paid to it by the new tenant until a shut-off notice has been given; then the trouble begins.

If a guarantee deposit has been made by the previous tenant it is very easy to make a deduction from the deposit for the amount of the bill; if no deposit, then the only alternative is to proceed to collect from the new tenant who has substituted himself for the old one by using water without first making application and signing a contract.

Requiring a guarantee deposit to secure the payment of water bills is important and requires discrimination without apparent favoritism.

It is good practice to require deposits in each case from renters, where the owner of the property will not sign a guarantee contract, and also from owners who are always in a chronic state of arrears.

[1] Presented before the California Section meeting, October 25, 1929.

[2] Controller, Department of Water and Power, Los Angeles, Calif.

Meters should be read for billing as nearly as possible each thirty days.

Meter readers should be trained to notice any great difference in present as against average readings. If there should be a noticeable difference in the consumption, whether more or less, and no apparent change in the use of water on the premises, it should be reported immediately so that an inspection can be made and the consumer notified if a leak exists, or perhaps the meter is not operating and requires overhauling.

Prompt notice of unusual bills saves many misunderstandings and if adjustment has to be made, it is better to do so immediately than to wait until some future time, when conditions may have changed sufficiently to make it next to impossible to arrive at a fair adjustment. Prompt rendering of bills is very important.

If there has been an excessive use and a large bill is the result, the consumer should receive his bill promptly, thereby giving him an opportunity to correct the trouble if it exists.

Adjustments should not be made unless the large bill is the result of an accident or from some cause not under the user's control. If you begin to make adjustments and allow rebates, except for waste not under the control of the consumer, you will never know where to draw the line.

The person who insists upon a rebate and states that it is not the amount of money but the principle involved, is usually not sincere. More than likely the reduction in the bill is what he wants and he will be satisfied with nothing else.

Bills should be rendered promptly. The sooner a bill is in the hands of the average person, the sooner it will be paid. The longer the delay in getting bills out, the greater will be the loss from uncollectible bills.

Meter readings should be checked when extensions are made by the office force and bills made and mailed as soon as possible.

Adjustments should be made at the office whenever possible, as it is easier in most cases to come to an understanding there than at the home of the complainant. "A dog under his own wagon is hard to handle."

The selection of inspectors and adjusters should receive serious consideration. These men must be neat in appearance and should possess considerable poise and be of sound judgment. It will be part of their routine to stand abuse without retaliating.

Collections by mail are the cheapest, although collectors can hardly be dispensed with as a visit to the premises may be required in many cases when no reply is received from a mailed bill. The customer may be temporarily absent or there has been a change of tenants.

In case there is a new tenant it is necessary to learn, if possible, the whereabouts of the previous tenant owing the bill, and also to have the new tenant sign up for the use of the water.

The stub bill system is very good for a follow-up of collections. If the bill is not paid in say fifteen days after mailing, the delinquent stub can be detached and mailed or sent out by a collector. By this system it is only necessary to check over the unpaid accounts, which are readily seen as the stubs on the paid bills are detached at the time the payment is posted and the unpaid ones only remain.

If the business is large enough and there are many accounts, the tabulating machine card system works admirably in checking unpaid accounts, as well as in many other particulars.

Charges for unusual items, such as damaged meters, and bills of that nature should be discussed with the person responsible for the damage and an understanding reached, if possible, before the bill is rendered. Otherwise a great deal of time is consumed and expense incurred before the bill is collected.

The regular monthly bills are not troublesome to collect, but those for the unusual items and for closing bills are hard to collect and expensive.

The consumers' bill should be simple, easily understood and without too much text.

The subject of district or sub-offices is always a problem in large communities.

The consumer cannot understand why an office should not be maintained in his locality for his convenience.

It is more efficient and economical to keep the accounts and bills at a central or general office, rather than to divide this work by doing some of it at a branch office. Just how much should be done at a branch or district office is a question.

It does not pay to maintain a very high priced efficient force at a small office, but rather one understanding the detail of the business.

Whether anything more than taking orders and collecting bills should be done at a branch office is debatable.

It is difficult to obtain prompt reports of orders and collections unless a messenger service is maintained, and, if the territory covered

by the utility is large, the expense of such service is out of proportion to the amount of business usually done at a branch office.

Much has been said regarding shut-offs for delinquent bills. It is difficult to establish an inflexible rule in this respect; there are so many exceptions worthy of consideration.

If it were possible to secure the proper legislation in this state making the charge for water a lien against the property served, there would be little necessity for shutting-off water on account of delinquent bills. There is, however, quite a difference of opinion in regard to such legislation.

ELECTRIC PUMPING AT BELOIT, WISCONSIN[1]

By C. F. Dobson[2]

Beloit is a city of about 25,000 located on the Rock River just north of the Illinois Wisconsin state line in central southern Wisconsin. It is predominantly an industrial town, although surrounded by a very prosperous agricultural region. The town of South Beloit, Ill., is just across the state line and in every way except in government is integral with and may be considered a part of Beloit.

The combined area included in the two communities is 6 square miles and is now served by approximately 65 miles of mains on which are 480 hydrants located.

The area drained by the Rock River through this section of the state is underlaid with water bearing gravel, which varies in depth from a few feet to about 300. Because of this and because the Rock River is badly polluted, the original installation of the water works at Beloit was of driven wells put down in this gravel at depths varying from 75 to 130 feet. These wells gave an adequate supply for the city at that time and, as more water was needed, it was a comparatively simple matter to obtain an additional supply from this source.

The original pumping equipment at Beloit consisted of two Smith-Vale reciprocating steam pumps to which was added a short time later, more for fire protection than domestic supply, a large capacity Fairbanks-Morse steam reciprocating pump.

A few years later more water was required, particularly on the west side of the river. To take care of this need there was built what was known as the West Side station. As in the original station the water was obtained from driven wells in the gravel supply. The pumping was done by water wheels, which operated horizontal double acting reciprocating pumps.

In addition, a pumping station was located adjacent to the electric generating station. This was a shallow well station pumped by horizontal centrifugal pumps driven by electric motors.

[1] Presented before the Wisconsin Section meeting, September 17, 1929.
[2] Division Engineer, Wisconsin Power and Light Company, Beloit, Wis.

This, briefly, was the setup of the water stations of the city from 1885 to 1926.

The piping in all the stations was so arranged that the pumps operated on headers connected solidly with the well casings. Priming, in the case of the centrifugal pumps, was accomplished by means of a vacuum pump.

The system was designed to operate with an elevated storage tank maintaining the domestic pressure with the pumps pumping directly against this pressure. Fifty pounds were considered adequate during the early days, with the pressure being raised to 100 or 125 pounds during periods of fire. This was accomplished by closing the valve to the standpipe and pumping under direct pressure.

In 1902 additional storage capacity was needed for short periods of excessive demand, presumably during periods of fire, and a 500,000 gallon reservoir was constructed at this site.

TABLE 1

Kilowatt hour consumption per million gallons

East Side Pumping Station	1.28
Electric Pumping Station	1.21

In 1915 the two original Smith-Vale steam pumps were replaced by Fairbanks-Morse horizontal centrifugal pumps driven by General Electric synchronous motors. The piping on these two new pumps was so arranged that they could both pump against normal pressures or pump in series against fire pressures.

It was found in connection with the ground supply that, due to gradual corrosion of screens and filling up of the coarse gravel surrounding the points, it was necessary to abandon old wells and drill new ones to take their places; so that during the period from 1885, when the system was started, to the present there have been 19 of the old wells abandoned and new ones driven.

It is interesting to note, however, that during this period there has been no general recession of the ground water level and when it has been necessary to augment the supply, the addition of a well or two in this same immediate area has furnished the required additional amount of water.

Since raising the pressure, the west side hydraulic station has been abandoned, due to failure of the wells and pumps. The other station

is still used during heavy demand periods, but will be retired when the present wells fail.

Table 1 gives the average power requirements for the electrically operated stations obtaining their water from the gravel wells and pumping against 50 pounds.

NEW DEEP WELL SUPPLIES

In 1926 the growth of the city had been such as to make the existing equipment inadequate, particularly during the high demand of the summer months. After a great deal of consideration it was decided that there was much to be gained from the installation, at various points on the distribution system, of isolated electrically driven centrifugal pumps operating on deep wells.

It was thought that, as time went on and the density of population became greater, there would be more and more chance of possible contamination of the gravel supply. There were records of a number of successful wells which had been drilled into sandstone in the Rock River valley, so this source of water supply was turned to at this time. Deep well turbine pumps were naturally selected for these wells as they adapt themselves admirably to high outputs and automatic control through electric drive.

During this year a well was drilled on the east side of the city to a depth of 957 feet. This well was equipped with a 9 stage deep well turbine pump with a bowl setting of 100 feet. This pump is driven by a 150 h.p., 4000 volt wound rotor type motor and delivers approximately 1200 gallons a minute against the normal domestic pressure.

At this time, also, it was decided to raise the domestic pressure from 50 to approximately 75 pounds, due to the fact that certain elevated sections of the city were not obtaining sufficient pressure for their ordinary needs. This was accomplished by the installation of a 200,000 gallon elevated steel storage tank set at the proper elevation to give this pressure.

In 1927 it was found necessary to drill an additional deep well. This was located in the opposite side of town and was drilled to a depth of 1225 feet and equipped with a 10 stage deep well turbine pump with the bowl set at 140 feet from the surface. This pump is equipped with a 150 h.p. motor and delivers about 1350 gallons per minute against the normal head. These two deep wells, together

with the motor driven equipment of the original installation, furnish the water supply for the City of Beloit.

Both deep well pumps are equipped with automatic pressure control, which to date has operated perfectly.

At present we have three 8-hour shifts of one man each at the east side station to control the pumps on the shallow well system and take care of raising the pressure during fire, but we expect to be able to cut down on this labor when the deep well system is complete.

Due to the fact that most of the old equipment is operating under conditions other than it was designed for, the output in gallons per kilowatt hour for the various stations varies considerably.

Table 2 gives some information on what the various stations did per kilowatt hour in August.

TABLE 2

Kilowatt hour consumption per million gallons—August, 1929

East Side Pumping Station	1.26
Deep Well No. 1	1.13
Deep Well No. 2	1.66
Electric Station	3.9

You will notice from the above that Deep Well No. 2 is somewhat higher in consumption than either the East Side or Deep Well No. 1. This is due to an excessive draw down which affects this pump by making it operate against a higher head than it was designed for with a decline in efficiency. At that, a recent test on this pump indicated an efficiency of 63 percent.

POWER

Present day electrical power lines such as are now built in distribution work are so constructed as to furnish reliable power at outlying stations.

Our east side pumping station, located about two blocks from the generating station, is served by two lines. During the period since 1915 that this station has been operated by electricity there has been only one time when the power failed on the line. That occurred when a ditcher cut into the cable when the city was laying a sewer.

The new west side well is supplied from a 13,200 volt feeder about two miles long. In the two years of its operation no shutdown

has been occasioned by loss of power for more than two minutes and in each case the pump started automatically after the shutdown.

In general, the advantages of electric drive are—

Flexibility

It is possible with electrically driven equipment to locate the stations wherever they may be needed and the operation is very flexible in that with the dependable automatic controls now available each unit can be set to operate only when needed. There are no expensive standby operating costs piling up during the period of shutdown.

Operating labor reduced

Automatic control also eliminates the need of considerable labor charges. The attending labor can be reduced to daily inspection and oiling which can be done by one man on part time.

Reasonable maintenance

Our units have shown us that there is very little maintenance to be anticipated with these units. Electrical equipment is reliable and the maintenance on the pumps during the three years of operation has been negligible.

Decreased investment

Because of the small space required for this type of unit and the small building needed, the investment charges will be less than on most systems. This is helped, too, by the fact that in our case additional units will be placed in outlying districts where land values are not high.

PUMPING AND FILTRATION COSTS OF A SMALL TOWN WATER SYSTEM[1]

By W. S. Davis[2]

The Tennessee Electric Power Company operates several water systems of various sizes in Tennessee. The one described here serves a community with a population estimated at 5,800. The system at the present time has 1,000 customers.

The costs mentioned in this paper have reference to the operating costs at the pumping station and filter plant only. They do not include any of the many operating costs of the distribution system, customer services, meters, collection costs or any fixed charges. The water source is said to be one of the softest in the United States. It is a river fed by mountain streams. During the driest summer seasons the stream flow has been in excess of 50 million gallons per day.

We will begin at the intake tower and give a brief description of the layout and equipment. This intake tower is of concrete construction. It is approximately 8 feet by 10 feet by 40 feet deep, equipped with the necessary screens and two 12-inch cast iron pipes extending into the river about 60 feet. On the opposite side of the intake tower, there are two 12-inch suction pipes about 100 feet long connecting to the low service pumps, which are located in a well or pit 16 feet in diameter and 36 feet deep. Two low service pumps are located in the bottom of this well. From the low service pumps, one 6-inch discharge pipe leads to the agitation chamber of the coagulation basin, a distance of 100 feet. In this chamber Alco-floc and alum are introduced. The water then passes over and under several baffles and requires approximately five hours to reach the end of the coagulation basin. The water is then ready to pass to and through the filters by gravity, and into the clear well. The filters are of the gravity sand type, with a rated capacity of 500,000 gallons each in 24 hours.

The filters are located in the filter house which is a single story,

[1] Presented before the Kentucky-Tennessee Section meeting, January 26, 1929.

[2] Tennessee Electric Power Company, Harriman, Tenn.

fire proof, brick structure, approximately 40 feet square with a concrete basement. This building also accommodated the laboratory, lime and alum machines, chlorinating equipment and also the high service pumps and filter washing pump which are located in the basement.

After the water passes through the filters, it enters the clear well, which is located about 12 feet south of the filter building. The clear well is of concrete construction and is covered with a reinforced concrete top.

The dimensions of the clear well are 16 feet deep, 29 feet wide, and 69 feet long. Its capacity is approximately 225,000 gallons.

The water is then pumped by the high service pumps from the clear well to the distribution system and the storage reservoir. This reservoir is located on the hillside about 5,000 feet from the filter plant, and it is 340 feet higher than the high service pump. The main feeder for the distribution system and reservoir is a 10-inch cast iron pipe.

The storage reservoir is pentagonal shaped, 13 feet deep and is covered with a reinforced concrete top. Its capacity is approximately 750,000 gallons.

The foregoing description gives you a fair picture of the system. We will now return to a more detailed description of the pumping equipment and give some pumping costs.

LOW SERVICE PUMPS

The low service pumps consist of one 700 g.p.m. Cameron centrifugal, single stage, direct connected to a 15 h.p. 1200 r.p.m. induction motor and a 500 g.p.m. Cameron centrifugal, single stage, direct connected to a 15 h.p. 1200 r.p.m. induction motor.

Each of these pumps is connected with the intake well by 12-inch cast iron pipes. The average suction lift is approximately 15 feet. Both pumps are connected to a single 6-inch discharge line equipped with the necessary valves. The discharge head to the coagulation basin is 45 feet, making a total static head of 60 feet. Only one pump is in operation at any time. In order to give you a better picture of the actual operating conditions, we have chosen one month in the summer when the turbidity of the river water was comparatively high, and one month in the winter when the turbidity was low. During the summer months we maintained an operator on both day and night shifts, while later on we were able to dispense with the night operator.

This was accomplished by the installation of a filter wash pump which permitted washing the filters during the day instead of at night, which had been the usual practice. Previous to the installation of the filter wash pump, to wash the filters it was necessary to use water from the distribution system and reservoir. This had to be done after most of the customers had retired, due to the fact that customers in the higher parts of town could not get water while the filters were being washed.

Another reason for installing the wash pump was, that it was not considered economy to pump water into the reservoir and then use it later for washing the filters. With the old method it required about 25,000 gallons to wash the filters, while with the present it requires only 12,000 gallons and it is much more effective.

The average cost per 1,000 gallons delivered to the coagulation basin for a typical summer month of last year was 1.17 cents. The gallons pumped for the month (June) were 10,142,800. Your attention is again called to the fact that all cost figures are for only pumping and filtration operation.

The average cost per 1,000 gallons delivered to the coagulation basin for a typical winter month of last year was 0.866 cents. The gallons pumped for the month (December) were 12,324,800.

In the agitation chamber of the coagulation basin the chemicals (Alco-floc and alum) are introduced and the water passes through the filters and then to the clear well. The chlorine is introduced at the rate of approximately 0.043 p.p.m.

THE HIGH SERVICE PUMPS

The filtered water is then taken from the clear well by two high service pumps, rated at 300 and 800 g.p.m., pumping against a head of 340 feet to the distribution system and to the 750,000 gallon concrete reservoir located about one mile from the filter plant. The smaller pump is an Allis-Chalmers, 3 stage centrifugal, direct connected to a 50 h.p., 1750 r.p.m. induction motor. This outfit is only used as a standby.

The larger pump is a Cameron, 3 stage centrifugal, direct connected to a 125 h.p., 1750 r.p.m., slip ring induction motor.

The average cost for taking water from the entrance of the coagulation basin through the filters to the reservoir for the same summer month of last year, previously referred to, was 6.129 cents per 1,000 gallons, and the amount 10,142,800 gallons. The average cost for

the winter month was 4.54 cents per 1,000 gallons, and the amount 12,324,800 gallons. This includes chemicals and filter operation.

Combining the pumping costs from the river to the reservoir we find for the summer month an average cost per 1,000 gallons of 7.56 cents and for the winter month, of 5.4 cents.

The average running time for the low service pump is 10 hours and 8 minutes per day. The average running time for the high service pump is 7 hours, 49 minutes per day.

The following additions and improvements have been made in the last two and one-half years:

1 low service pump
1 sump pump
1 high service pump
1 filter washing pump
And a reinforced concrete top placed on the storage reservoir.

The cost of power for operating the pumps is based on The Tennessee Electric Power Company's standard wholesale power rate "A" applicable to industrial customers. This rate carries a demand charge of $1.50 for the highest 15 minutes kilowatt demand during the month and an energy charge starting at 4 cents per kilowatt-hour for the first 500 kilowatt-hours used per month and steps down to 0.5 cent per kilowatt-hour for all in excess of 700,000 kilowatt-hours used per month with a 5 percent cash discount.

SAFEGUARDING AND ELIMINATING CROSS CONNECTIONS IN NEW YORK STATE[1]

By C. A. Holmquist[2] and Earl Devendorf[3]

Cross connections between public water supply and auxiliary industrial and fire supply systems from various polluted sources have been much discussed by leading water works and public health authorities through the past decade. Not alone in New York State, but throughout the United States, numerous outbreaks of waterborne disease, attributed to polluted water entering the public water supply systems through various types of cross connections, have occurred.

At the penalty of being burdensome, it is believed well to review briefly the action of some of the leading water works associations on this subject during recent years. In 1925, the Fire Prevention Division of the American Water Works Association adopted the following resolutions:

Whereas cross connections between potable public water supplies and supplies from other sources have been the cause of a large number of outbreaks of typhoid fever and other waterborne diseases; and

Whereas check valves and other similar protective devices cannot always be dependend upon; Be it

Resolved, That no physical connection should be permitted between a potable public water supply and any other supply except as follows:

1. With another potable public supply.
2. With a potable supply which is regularly examined as to its quality by those in charge of the potable public supply to which the connection is made.

This prohibition to apply to all piping systems either inside or outside of any building or buildings: and be it further

Resolved, That definite programs should be inaugurated in each municipality to permanently eliminate all other connections.

Similar resolutions were adopted in 1926 by the Conference of State Sanitary Engineers. In December, 1928, a committee of the New

[1] Presented before the Toronto Convention, June 28, 1929.

[2] Director, Division of Sanitation, State Department of Health, Albany, N. Y.

[3] Associate Director, Division of Sanitation, State Department of Health, Albany, N. Y.

England Water Works Association presented the following resolutions for consideration by the association which were later endorsed through letter ballot:

WHEREAS, evidence shows that the existence of certain cross connections between safe public water supplies and unsafe private water supplies, not equipped with modern protective devices, has resulted in many out-breaks of disease and many deaths, and

WHEREAS, such cross connections are a hazardous part of any water supply system,

1. This Association recommends that no cross connection be permitted with a supply that in the opinion of the State health authorities is bacterially unsafe.

2. This Association recommends that any cross connection permitted with a bacterially safe, but non-potable supply shall be made through a properly installed and adequately supervised, all-bronze, rubber-seated, double check valve of a type approved by the State health authorities.

In May, 1928, a report of the Committee on Private Fire Supplies from Public Mains of the National Fire Protection Association embodied the following:

1. The National Fire Protection Association is in full sympathy with the efforts being made to maintain the purity of public water supplies. It recognizes a public duty in bringing fire protection requirements into harmony with the best public health standards.

2. Fire protection engineers should not advocate cross connnections with nonpotable supplies for fire service when it is feasible to safeguard life and property in some other way.

3. No fixed rule can be adopted for all situations, and each case must be carefully studied to determine the most reasonable arrangement under the existing conditions.

4. The chance that the best double special check valves properly supervised might, under conceivable conditions, both leak at the same time has been conceded, but experience of eighteen years over a wide field and under many different conditions has shown that this danger is extremely remote. It is, therefore, believed that double special check valves of the latest improved all-bronze type can be used under certain conditions with a negligible degree of risk, but only if properly installed and adequately supervised.

5. Public regulations concerning cross connections should have reasonable flexibility so that double special check valves or other equally effective devices properly supervised would be allowed for fire services where conditions justify their use.

The Public Health Council of the State of New York after a prolonged and deliberate study of the problem of cross connections between potable and non-potable water supplies, enacted, in Novem-

ber, 1925, the following regulations, known as Regulations 15-a and 15-b of Chapter VII of the Sanitary Code, requiring, by July 1, 1928, the elimination of such cross connections in New York State:

Regulation 15-a. Certain cross connections between water supplies not permitted. No officer, board, corporation or other person or group of persons, owning or having the management or control of any potable water supply furnished to any municipality or water district, shall permit after July 1, 1926, any physical connection between the distribution system of such supply and that of any other water supply, unless such other water supply is regularly examined as to its quality by those in charge of the potable water supply to which the connection is made and is also found to be potable. This prohibition shall apply to all water distribution systems either inside or outside of any building or buildings.

Provided, that, where such physical connections now include two gate valves with indicator posts, two check valves of the Special Factory Mutual Fire Insurance design or equivalent with drip cocks and gauges for testing, all located in a vault of watertight construction accessible for ready inspection, the date of discontinuance may be extended until July 1, 1928.

Regulation 15-b. Permissible arrangements where dual supplies are used. If a potable water supply is used as an auxiliary supply delivered to an elevated tank or to a suction tank, which tank is also supplied with water from a source with which cross connections are not permitted by Regulation 15-a, such tank shall be open to atmospheric pressure and the potable water supply shall be discharged at an elevation above the high water line of the tank.

Subsequent to the enactment of these regulations, protests of representatives of certain industries in the state were made to the Public Health Council. Following these protests, the Council conferred with manufacturers, health officials, water supply officials, sanitary engineers, fire protection engineers and insurance organizations and held numerous hearings in various parts of the state. As a result of these hearings the Council became convinced that the severance of connections between potable and polluted waters was demanded for the protection of the public health.

In view of the various hearings held and the time consumed, a great many industries had delayed taking active steps to make the necessary construction changes to conform with the regulations of the Code. Accordingly, requests were received from a considerable number of industries, requesting extensions of time, due to delays, many of which were unavoidable, in having the necessary changes made to comply with the Code. Moreover, in May and June of 1928, a new development in chlorination apparatus was brought to our attention which, it was thought might possibly permit certain plants to chlori-

nate their auxiliary supplies and render them potable from a public health standpoint. Tests of this so-called special fire pump chlorinator equipment were made covering a period of some six weeks, as a result of which it was determined that the apparatus with proper supervision would be capable of effectively chlorinating an auxiliary supply under intermittent operation of fire pumps and thus rendering such auxiliary supply potable, provided it was only moderately polluted. Such installations must, however, meet the following requirements:

1. The water supply must not be so grossly polluted that it cannot be effectively chlorinated.
2. The fire pump must either take suction from an open well or sump or there must be a municipal water supply available having a pressure at least three times as great as the pressure on the suction of the pump.
3. The chlorination equipment must be of a type approved by this Department and so equipped as to continuously waste a small amount of chlorine solution and provided with solenoid or steam operated valves so regulated that immediately upon the starting of the pump it will apply chlorine at a rate of not less than twenty pounds of chlorine per million gallons of water pumped.
4. Platform scales must be provided for checking the loss of weight of chlorine.
5. Plans of the installation, together with report and sufficient data to pass upon it, must be submitted for approval to both the local water authorities and to the State Department of Health.
6. Reports of the results of daily orthotolidine tests of the chlorine solution wasted and the amount of chlorine wasted or used per day must be submitted at least monthly to the municipal water supply authorities.
7. Chlorinators on all auxiliary industrial or fire supplies must be inspected regularly and at frequent intervals by local water supply authorities.
8. The cross connection between a potable municipal supply and a chlorinated auxiliary industrial or fire supply must be equipped with double check valves of the "all-bronze" type placed in an accessible chamber and properly equipped for testing and inspection. Such check valves must be inspected and tested at least monthly and taken apart, thoroughly cleaned and any worn parts replaced at least yearly.
9. Discharge valves on the fire pumps must be closed whenever the pumps are turned over for testing.
10. Any approval by the municipal and water supply authorities or this Department will be given only on condition that the chlorination apparatus is satisfactorily installed, operated and maintained at all times.

To date some 60 fire pump chlorinator installations have been authorized among 55 of the industrial plants in the state. A recent report of one of the insurance associations on the results of plant changes made to comply with the provisions of the Code, show that out of a total of some 147 plants listed, the total estimated cost of changes necessary to comply with the Sanitary Code was about $350,000. These changes included installation of all-bronze check valves in pits, erection of gravity and suction tanks and changes in yard piping. It was estimated that the cost of heating gravity and suction tanks would be from $250 to $400 annually. It is further estimated that the fire pump chlorinators would use up approximately $110 worth of water and chlorine per year, besides the necessary supervision, making a total annual maintenance charge for the chlorinator of say $200.

In some special cases, considerable expenditures have been necessary to eliminate satisfactorily cross connections and at the same time provide industries with adequate fire protection. In one of these instances, the industry spent over $25,000 in placing new mains to carry the polluted water supply and thus eliminate the cross connection with the public water supply.

It must be borne in mind, however, that, in our program of safeguarding cross connections, it has been our endeavor to eliminate the cross connection wherever possible. Moreover, the quality of the water supply to be treated is carefully considered. In six instances, applications for permits for the installation of a fire pump chlorinator were denied, because it was found the sources of the fire pump supplies were too polluted to permit reliance upon chlorination. Furthermore, in all instances where fire pump chlorinators have been installed, it has been required that double check valves of the all-bronze type be installed in place of the old iron body type.

Investigations have been made with pubic water supply authorities and representatives of industries, with particular reference to the elimination of cross connections. In the majority of these instances some satisfactory and reasonable plan or program could usually be found for eliminating the cross connection. In all instances, in which permits have been granted for the installation of fire pump chlorinators, the need for careful and constant supervision of the apparatus has been emphasized. In fact, it has been pointed out that, should the fire pump chlorinator be neglected, the permit would

be revoked and the industry would be required to eliminate the cross connection.

The earlier fire pump chlorinator installations have been in service at the time of this writing for some six months. The majority of them have been in operation at least four months. Monthly reports on the daily results of tests and observations of the operation of the chlorinators received by the Department indicate that the fire pump chlorinators have, with minor exceptions, operated satisfactorily.

Inasmuch as this has been an entirely new departure, it was to be expected that some features might develop which might not be entirely satisfactory. There have been but few instances, however, where such conditions have occurred. Where they have, it has been possible to determine and correct the cause. Although six months would be somewhat too short a time to predict with certainty the future of the fire pump chlorinator, it would appear that, given proper and careful daily supervision and maintenance, the equipment is capable of satisfactorily chlorinating an auxiliary supply under intermittent operation and rendering such auxiliary supply potable, provided it is only moderately polluted.

A so-called swing joint arrangement has also been developed which, so far as is known, has not hitherto been employed, at least on a commercial plant size scale, to make available either one of two water supplies. By this type of arrangement, the city supply, which is normally used, can be shut off and the industrial distribution pipe line changed by means of a swivel joint to connect with the fire pump supply which, thereafter, can be placed in use. Although such a system has been approved by the State Health Department in a few instances under certain conditions, the insurance authorities have not looked entirely with favor on this type of connection, except under very favorable situations, inasmuch as it is open to the following possible objections:

1. There is a period of time during the making of the change when no water supply pressure is available.

2. Instead of having two sources of supply available simultaneously for fire fighting purposes, as is the case where both the city and the fire pump supplies are connected through suitably arranged check values, there can be only one source of supply used at a time. So far as we know there have been only about a half dozen of such installations throughout the state.

In addition to these cross connections on fire supply lines and mill

service supply lines, cross connections have been found on water service lines for priming pumps, for boiler feed, for cooling purposes, etc., usually made for use in emergency to obviate shutting down some piece of machinery and frequently made for convenience or through ignorance. When such cross connections have been discovered and the matter has been taken up both with the authorities in charge of the water supply and the owner of the property or the industry, prompt steps have been taken in all instances to eliminate these cross connections which may oftentimes be more dangerous than the well regulated and supervised larger type of cross connections.

Although the Sanitary Code places the responsibility for eliminating cross connections on the local water supply authorities, the Department has been called upon for advice and assistance by the local water supply authorities as the problem of eliminating cross connections, particularly in the larger industries, involves special engineering problems. The importance of making careful inspections of piping systems at industrial plants to discover any possible cross connections has been forcibly brought to our attention and we have emphasized to the local authorities the need for such inspections. Painting pipe lines in colors or with colored bands will undoubtedly greatly reduce the hazard from cross connections made through ignorance or carelessness. Such standards are already in use in power plant practice.

Although conditions are found to be somewhat similar in numerous instances, there are hardly any two plants having the same hydraulic conditions. A careful study has been necessary of the conditions at each plant in order to determine the most satisfactory and economical method of eliminating the cross connection. Moreover, in all cases the industries and manufacturing establishments have been advised to take the matter up with their fire insurance authorities, in order that any improvements or changes in the piping system would be made with the approval of the fire authorities.

In this brief summary of the action taken to eliminate cross connections in New York State, acknowledgement should be made of the splendid coöperation and assistance rendered by the representatives of industries and insurance authorities. Without their coöperation, the progress already made in this important and large undertaking could hardly have been accomplished within so short a time.

SOME IDIOSYNCRASIES OF GROUND WATERS[1]

By W. D. Gerber[2]

Most persons in this state, especially those residing north of an east and west line through Casey and Carlinville, have the deeply rooted opinion that the best water for a public water supply is to be obtained from subterranean sources.

In one sense of the word this, no doubt, is true, (provided the well is properly constructed to exclude wash from the surface), for as a general rule such waters are free from bacterial contamination and are pleasing to the taste. However, the bacterial purity of a water is not the only desirable attribute, especially in communities where prosperity and happiness depend upon industries and their development.

The State of Illinois may be called a "hard water" state for the average hardness of the ground waters is probably in the neighborhood of 350 p.p.m. or more.

From a chemical analysis of the mineral content of something over 400 well waters it is found that the hardness varies from 16 to 1130 p.p.m. The residue varies from 200 to 5050 p.p.m. and the iron content from 0 to 10 p.p.m.

From the standpoint of boiler use, undoubtedly the greatest industrial use to which water is put in the state, the hard scale forming minerals are perhaps the most serious, while the corroding and foaming waters follow closely.

The hard scale forming elements vary from 4.5 to 1150 p.p.m. and there are wells which are yielding from 1000 to 1250 p.p.m. of sodium chloride.

In general, those waters which are low in the calcium-magnesium hardness, are high in the sodium salts and vice versa.

In a rather detailed study of waters from 22 wells located in the north tier of counties, some interesting information came to light.

In making this study the wells were first grouped in terms of the

[1] Presented before the Illinois Section meeting, May 13, 1929.

[2] Division Engineer, Illinois State Water Survey Division, Urbana, Ill.

water bearing rock, for example, the first group included wells drawing water only from the lime rock; the second included wells drawing water from the St. Peter and above; the third wells drawing water from the Dresbach and above; and the fourth wells drawing water from the Mt. Simon and above.

There are other wells in this zone than those considered, but the information on record was not complete enough to permit them to be compared with the 22 selected.

In the first group, namely water drawn from the lime rock only, there is but one well, that at Elizabeth in Jo Daviess County, the

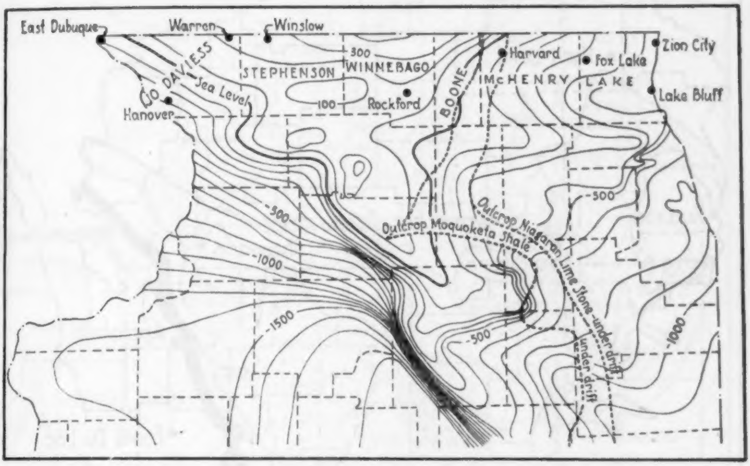


FIG. 1. STRUCTURE MAP OF NORTHERN ILLINOIS SHOWING CONTOURS ON TOP OF DRESBACH SANDSTONE

westerly county of the strip. This well is so constructed that all the water is obtained without question from the lime rock which in this location is of the Galena-Platteville formation.

As would be expected the water is high in calcium and magnesium with a hardness of 477 and a residue of 559 p.p.m. The chlorides are low, but the sulfates are sufficient to produce some hard scale if the water is used for boiler purposes.

In Lake County, which is on the easterly end of our strip the limestone is known as the Niagaran, a younger formation than the Galena, and water from it is very likely to be highly sulfurous.

The St. Peters sandstone which underlies this strip of Counties was the first sandstone to receive attention as a source of water supply.

Eight wells into this horizon have an average hardness of 323, the lowest having a hardness of 149 and the highest 416 p.p.m.

While all these wells terminate in the St. Peters sandstone all but one are open to the superimposed lime rock and are, therefore, not

FIG. 2

strictly representative of St. Peter water, but are a combination of the water from both water bearing rocks. In the case of the one well at Winslow, the limestone water is cased off and the analysis may be considered as a sample of St. Peter sandstone water.

In this group of 8 wells there is a progressive deepening of the wells from west to east and an increase in temperature in the deeper over the shallower wells.

Perhaps the most interesting feature, however, is that the four wells west of Rockford show an average hardness of 361, while the four east of Rockford show an average hardness of 284 p.p.m. The residue, however, remains about the same on either side of the line at an average of 400. The methyl orange alkalinity averages 341 for the west group and 278 p.p.m. for the east group.

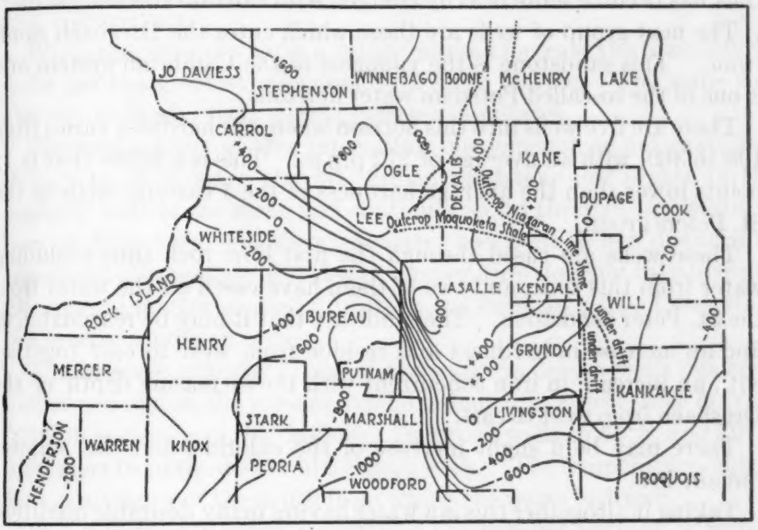


FIG. 3. STRUCTURE MAP OF NORTHERN ILLINOIS SHOWING CONTOURS ON TOP OF ST. PETER SANDSTONE

The four westerly wells show a total of all sodium salts of 192, while the easterly wells have a total of 397 p.p.m. In general, there is a greater concentration of sulfates in the four eastern wells but a less concentration of carbonates.

In connection with the St. Peters sandstone and the mineral quality of water therefrom, it may be interesting to note the shape of the contours of the top of the St. Peter sandstone, as shown on figure 3.

This map indicates the great disturbance that took place after the deposition of the various rocks up to and including the Niagaran limestone. Later erosion planed off the arch this formed and with

it a considerable portion of these more recently formed rocks. This is particularly true of the portion of the strip from somewhat east of the west line of McHenry County, west, where practically all of the Niagaran limestone has been removed together with much of the Maquoketa shale which immediately underlies it.

It may be that the increase in hardness in the westerly group of wells is due to the removal of the protective coating of the Maquoketa shale thus permitting the absorption by the St. Peters sandstone of water which has passed through the Galena Plalieville limestone and thus has become more heavily charged with calcium and magesium.

The next group of wells are those which enter the Dresbach sandstone. This sandstone is the youngest of the Cambrian system and is one of the so-called Potsdam water horizons.

There are five wells into this horizon where the hardness varies from 198 to 360, with an average of 272 p.p.m. This is a figure that is 12 points lower than the average hardness of the 4 easterly wells in the St. Peters group.

These wells are cased through the first lime rock thus excluding water from this zone, and two of them have cased off the water from the St. Peter sandstone. They indicate that it may be reasonable to find an increase in hardness and residue from west to east together with an increase in iron concurrent with the increasing depth of the Dresbach from west to east.

There may be a slight increase of the chlorides but the sulfates remain low.

Taking it altogether this is a water having many desirable qualities, and, if found in sufficient quantity to supply the demand, can be economically developed, as it is not excessively deep.

The last group consists of eight wells extending into the lowest of the water bearing sandstones, namely the Mt. Simon. It may be pertinent to state at this point that this sandstone is the deepest from which we may expect to secure satisfactory water.

This horizon is prolific in its yield, but is more highly mineralized than the others. We have no way of knowing just what the mineral content of water exclusively from the Mt. Simon is because all the wells from which waters have been analyzed are a mixture of water from all the water horizons passed through, it being the practice to leave open all the strata which are sufficiently rigid to sustain and maintain the open bore.

The eight Mt. Simon wells vary in depth from 1343 at E. Dubuque to 2269 feet at N. Chicago. As a group the hardness varies from 245

to 440, with an average of 353 p.p.m. The residue varies from 263 to 776, with an average of 479 and the M.O. alkalinity from 228 to 340, with an average of 277 p.p.m.

The interesting thing, however, is that in this group we apparently again have a demarkation between an easterly and westerly subgrouping, with the line of separation again somewhere between Rockford and Belvidere.

For the three westerly wells the average hardness is 263 while for the five easterly wells it is 408. Similarly the average residues are 285 and 595 p.p.m., respectively and the M.O. alkalinity 249 and 293, respectively.

While the chlorides show a rather marked increase the five easterly wells are the greatest offenders by a large margin. The same five easterly wells also show a great increase in sulfates.

The explanation of this interesting phenomenon is not easy, but it may be that, since the Mt. Simon sandstone lies higher in the westerly part of the state and continues so up through the westerly part of Wisconsin, the absorbed water has a much less distance to travel and also because of its lesser temperature does not take up soluble mineral matter so easily, while in the easterly part of the state the reverse condition is true.

The increase in temperature of the water in deeper wells has been mentioned and in the records available indicates a difference of from 50°F. in waters from the shallower lime rock wells to 65°F. and 70°F. for waters from the deeper Mt. Simon wells. The temperature, therefore, is an index of the depth from which the water is drawn.

In a comparison made recently of the mineral content of waters from the Mt. Simon sandstone wells in the vicinity of Maywood to Elmhurst it was found that in those wells deeper than 2050 feet there was a distinct tendency to high concentrations of sodium chloride. For instance, at Melrose Park with a depth of 2117 or −1485 sea level, the NaCl amounted to 1256 p.p.m. At Bensonville with a depth of 2291 or −1616 sea level the NaCl was 712, at Elmhurst with a depth of 2219 or −1554 sea level the NaCl was 850 p.p.m. Altogether there are eight wells in this general territory that have waters containing 400 p.p.m. or more of sodium chloride.

From this hasty outline it is evident that much information of scientific value would be obtained if we could arrange to have samples of water taken at intervals as the well progresses. The Water Survey is prepared to furnish containers for these samples and to make the analyses if advised from time to time of the progress of the work.

So far, deep or rock well waters have been discussed and it may be of interest to recite the efforts of a Central Illinois city in the hunt for an adequate supply of soft water. It is one of those cities which must secure its water from the drift if well water is to be used.

This little city is well located for development into a small industrial center and could easily become such if it had an adequate supply of soft water which it could offer to prospective as well as existing enterprises.

The Water Survey and Geological Survey were requested to coöperate with the municipal officials. The first step was a survey of the present water supplies for the various industries. In this survey some 17 waters were analyzed for their mineral content. The wells from which these waters were obtained are contained within a circle, the center of which is the Court House Building and having a radius of about 4800 feet.

This survey developed the information that the hardness of these waters varied from 175 to 800 p.p.m. The two wells from which the city obtained its supply had a hardness of 659 and 707 p.p.m., even though they were only about 65 feet apart.

A tabulation of the analyses showed that the hard waters were in the southwesterly, south and west parts of the city while the soft water wells so far developed were in the northeasterly part of the city.

It may be of interest to mention that the six wells giving waters with a hardness factor ranging from 175 to 250 p.p.m. were all located in a very restricted area, the extreme distance between any two wells being not more than 300 feet.

Some previous studies for a possible future water supply of better quality for this city indicated the possible location of such a source and this second survey confirmed the preceding conclusions to a considerable degree and recommendations that test wells be drilled were concurred in by the municipal authorities.

Four test wells all about 100 feet deep were constructed. The hardness of the water from these wells indicates very clearly that a water of a hardness around 200 p.p.m. is to be had, but that such water is located to the northeast of the city and outside the municipal corporation.

Complete delineation of the water bearing area has not been made, but it is hoped that the city administration will continue the work already started.

WORKING FOR INCREASED MEMBERSHIP[1]

By Otto S. Reynolds[2]

Information from Secretary Little's office shows the following ratio between members of the American Water Works Association in the state and the number of water works in each state: Iowa, 12.1 percent; Kansas, 6.1 percent; Missouri, 22.0 percent; Nebraska, 4.4 percent; South Dakota, 3.1 percent. The combined ratio for the Missouri Valley Section is only 11.2 percent. These figures show there is plenty of opportunity to work for new members.

While attending the Illinois Section meeting at Waukegan, it was stated that last year the Illinois Section was second on the records for securing the largest increase in membership for the year, 1928. The chairman then spoke encouragingly to make the effort to head the list this year. To start with, therefore, we may consider ourselves under challenged competition.

In this connection may I repeat the suggestion, that it would be a stimulation if a monthly record showing the results of the various Sections' efforts were published in the Journal. I really believe it would be effective even to list the names of the members, crediting them with the number of new members they have introduced and whose signatures they have secured on the applications. This does not mean credit should be given for the recommendations of the prospect. As the application blank does not carry such provision, one putting over a membership could sign his name on the lower left hand corner, thus indicating to whom the credit goes, regardless of the Section under whose jurisdiction that member belongs. In event two applications are introduced, the one to be credited should be the one to which the applicant's check is attached. In listing these, say high 20 or 30 workers of The Association, it might be well to include to what Section this worker belongs, and possibly his vocational connection. Of course, it would be possible for two or three workers to throw their combined efforts in favor of one by having the latter's signature previously signed as securing the

[1] Presented before the Missouri Valley Section meeting, November 6, 1929.

[2] The Leadite Company, Kansas City, Mo.

applicant (his name appearing in the lower left hand corner). Better this should not be encouraged. However, it may seem fitting to say "More power to the popular worker." On the bottom of the page or the next page a list of the new members received for that month with their addresses and positions would be very appropriate. Old members could then notice their friend's action and a word of congratulation should be in order—thus building up good will and causing that new member to encourage another friend to become a member.

At any rate, such a competitive stimulation would undoubtedly produce results. Whether or not it would be advisable to offer a prize is questionable. Personally, I would not take my time or any part of my Company's time to gain any prize. To attain the top of the list would be quite an accomplishment in itself. If at the end of the year the organization sees fit to recognize any extraordinary effort, let it be its pleasure. Preferably, however, the successful Section should carry such honors.

To talk Association membership to a prospect is an easy thing, for active members appreciate the value of the organization and the JOURNAL. The traveling man will find it often a fitting subject to approach in order to get away from his usual work. In any event to encourage a fellow water works man to join our fold should be admirable and appreciated by him sooner or later.

Just a word to our members whose duties require them to travel a great deal and come in contact with the various water works men over the country. To make an inquiry as to whether or not your client or patron holds a membership is often easy and fitting. If he is, congratulate him; if not, have an application blank about your brief case. Unquestionably, this class of men should head the proposed list, in that they have the superior advantage of traveling about. Also, in taking time to do this good work, undoubtedly closer contact will result between the two parties and thereby may be fruitful in more than one way.

There are many ways possible for the active member to secure memberships; letter writing, keeping it in mind when attending allied or other conventions, and actively holding the subject a warm and current topic among our associates.

Regardless of the above suggestions, let us all work for the increase of membership. At the end of the year may we show the largest annual increase of membership in the history of The Association.

SOCIETY AFFAIRS

THE MISSOURI VALLEY SECTION

The fifteenth annual meeting of the Missouri Valley Section was called to order by Chairman John W. Pray in the Hotel Cataract of Sioux Falls, South Dakota, on November 6, 1929, at 10:30 a.m. There were 46 persons present in the room. Mr. Ben B. Lawshe, Secretary of the Sioux Falls Chamber of Commerce, addressed the Section and officially welcomed them to Sioux Falls. Mr. Joseph S. Nelson, Water Commissioner of Sioux Falls, welcomed the Section on behalf of the Sioux Falls Water Department. Mr. John W. Pray, Superintendent of Water and Sewers of Fort Dodge, Iowa, Chairman of the Section, replied to the addresses of welcome and expressed the pleasure of the Section in having the opportunity to meet in Sioux Falls.

In accordance with the new provision in the Constitution of the Missouri Valley Section, the Report of the Nominating Committee written by its Chairman, Mr. Earnest Boyce, Director of the Division of Sanitary Engineering, Kansas State Board of Health, was read by the Secretary. The nominations for officers for the ensuing year were as follows: Chairman, Thomas J. Samuel, Jr., Kansas City, Missouri; Vice-Chairman, H. V. Pedersen, Marshalltown, Iowa; Directors: J. Chris Jensen, Iowa; W. Scott Johnson, Missouri; Homer V. Knouse, Nebraska; H. L. Brown, Kansas; Joseph S. Nelson, South Dakota.

Mr. Thomas J. Skinker of St. Louis, reported that he had visited Mr. Knouse on the way to the meeting and that Mr. Knouse had requested that, owing to his illness, Mr. David L. Erickson of Lincoln, Nebraska, be nominated in his place as Director. This substitution and the report of the Nominating Committee was approved.

Mr. Thomas J. Skinker, Engineer of Distribution, Water Department, St. Louis, was nominated for Director to represent the Missouri Valley Section on the Board of Directors of the American Water Works Association. Mr. Frank Lawlor of Burlington, Iowa, was nominated for Director for the American Water Works Association. The Reports of the Nominating Committee and the nominations

made from the floor were received and action on them deferred until the business session of the Section. The meeting then took up topics for round table discussion.

Topic One, "Methods of Collecting Past Due Accounts," was opened for discussion by H. V. Pedersen. Messrs. J. W. McAvoy, J. Chris Jensen, Thomas J. Skinker and Thomas Maloney took part in the discussion of this topic.

Mr. J. W. McAvoy opened the discussion of Topic Nine, "Fire Sprinkling Systems—Metered or Flat Rate?" Further discussion was carried on by Thomas J. Skinker, Geo. J. Keller, Phil Carlin and Mr. John Pray.

Topic Two, "Meter Troubles," was opened for discussion by Geo. J. Keller.

Topic Seven, "Who Should Pay for Re-Setting Hydrants," was discussed by H. V. Pedersen, J. W. McAvoy, J. Chris Jensen, W. W. DeBerard, Ed. F. Lee, Thomas J. Skinker, and John W. Pray.

Chairman Pray then appointed the following Committees: Resolutions—Thomas J . Skinker, Chairman, J. Chris Jensen, Phil Carlin, H. F. Blomquist and J. S. Nelson; Auditing Committee—H. V. Pedersen, Chairman, Geo. J. Keller. The meeting adjourned at 12:05 Noon.

The afternoon session of Wednesday, November 6, was opened by the Chairman, Mr. John W. Pray, at 2:15 p.m. The first paper by F. G. Gordon entitled, "Wells, Iron Removal Plant, and Diesel Pumping Equipment at Sioux Falls, South Dakota," was read and discussed. Mr. R. E. Bragstad, presented a paper on "The Sioux Falls Sewage Treatment Plant," which was discussed by Jack J. Hinman, Jr. Mr. Waldo W. Towne presented a paper on "Characteristics of South Dakota Water Supplies." This paper was discussed by C. H. Koyl, Charles A. Hunter and Earle L. Waterman. Mr. Jack J. Hinman, Jr., of Iowa City, Iowa, presented an illustrated paper on "Some Experiences in Operating a Filtration Plant in the Tropics." This paper was illustrated by lantern slides and was concerned with the new filtration plant at Barranquilla, Colombia, where Mr. Hinman worked during the past summer. The meeting adjourned at 5:15 p.m.

The meeting on Thursday evening, November 6, was called to order at 8:30 p.m. by Chairman Pray. Mr. Jack J. Hinman, Jr., President of the American Water Works Association, addressed

the meeting on the subject, "Aims and Purposes of the American Water Works Association."

A telegram was read from Mr. R. E. McDonnell expressing his regret that he was unable to attend the meeting. For this reason the paper on "The Colorado River Project," was not presented. In its place Earle L. Waterman read a paper entitled, "Factors of Safety in the Operation of Water Works." This paper received considerable discussion by Messrs. DeBerard, Hinman, Pray and Rhea Rees of the Sioux Falls Water Department. The meeting was adjourned at 10:45 p.m.

On Thursday, November 7, at 9:00 a.m., those attending the meeting of the Missouri Valley Section were taken by busses and automobiles on a trip of inspection to the Sioux Falls Sewage Treatment Plant and the Sioux Falls Water Works. The inspection at the Sewage Treatment Plant was conducted by R. E. Bragstad, and members of his staff. The visit to the Sioux Falls Water Works was directed by Rhea Rees and members of the Soux Falls Water Department. At the conclusion of the inspection at the water works, the members enjoyed a very good buffet lunch served in the pumping station. This lunch was provided through the courtesy of the Sioux Falls branches of Cochrane and Company and Crane and Company. Following the luncheon the party returned to the Hotel Cataract.

The Thursday afternoon meeting was called to order by Chairman Pray at 2:00 p.m. In the absence of the authors, H. E. Goresline, read a paper on "Notes on the Determination of Nitrates," prepared by G. W. Burke, Max Levine, and G. A. Nelson. The second paper of the Thursday afternoon program having been presented at the Wednesday evening meeting, Dr. E. P. Rothrock, State Geologist of South Dakota, Vermillion, South Dakota, gave a very interesting talk on "The Hot Water Basin of South Dakota." This talk had been suggested during the discussion of Mr. Towne's paper on "Characteristics of South Dakota Water Supplies." Messrs C. H. Koyl, G. G. Frary, State Chemist, Vermillion, South Dakota, and Earle L. Waterman took part in the discussion following the address. Dr. C. H. Koyl, then presented a paper entitled, "Railroad Water Problems and Their Solution." This paper was discussed by Jack J. Hinman, Jr., J. W. Pray, H. E. Goresline and J. J. Davenport. A paper on "Diesel Engines for Water Works Service,"

was then presented by R. L. Baldwin. The discussion of this paper was led by Geo J. Keller.

Following the presentation of papers, the meeting returned to round table discussion. Topic Eleven, "Covered or Uncovered Reservoirs," was opened for discussion by J. W. McAvoy and participated in by R. L. Baldwin, Thos. J. Skinker, C. D. Hays, R. J. Paulette, and H. E. Goresline.

Topic Sixteen, "Valve Boxes for Street Use," was discussed by Thos. J. Skinker, J. J. Davenport, and H. F. Blomquist.

Topic Fifteen, "Meter Boxes" was presented by Thos. J. Skinker. Topic Five, "Cement Water Pipe Joints," was discussed by Messrs. Skinker and E. B. Black.

Topic Fourteen, "Printed Annual Reports Showing Depreciation," was discussed by Thos. J. Skinker, H. F. Blomquist, E. P. Black, Phil Carlin, J. W. McAvoy, R. J. Paulette, and C. K. Mather. The meeting adjourned at 5:45 p.m.

At 6:30 p.m. on Thursday a pheasant dinner was served in the dining room of the Hotel Carpenter and this was followed by a dance. For those members who did not dance, tickets were provided for a boxing contest at the Coliseum.

On Friday, November 8, the last session of the meeting was called to order by Chairman Pray at 9:15 a.m. Mr. Pray announced that since the Missouri Valley Section was so fortunate as to have one of its own members present who was President of the American Water Works Association, he was going to ask President Jack J. Hinman, Jr., to preside at the meeting. Mr. Hinman then took the chair. Mr. H. E. Goresline read and discussed a paper on "Rapid Determination of the Colon Group in Water," prepared by Max Levine. This was followed by a paper on "The New Filtration Plant at Tulsa, Oklahoma," prepared by N. T. Veatch, Jr. This paper was read in Mr. Veatch's absence by E. B. Black of the firm of Black and Veatch. The paper was illustrated by lantern slides. Mr. Otto S. Reynolds then presented a paper entitled, "Working for Membership." The meeting then went into business session and Chairman Pray resumed the chair. The report of the Resolutions Committee was presented by its Chairman, Thomas J. Skinker, which was as follows:

Whereas: the Fifteenth Annual Convention of the Missouri Valley Section of the American Water Works Association, held at the Cataract Hotel, Sioux Falls, S. D., at which we have spent three profitable and enjoyable days, and

WHEREAS: we appreciate the efforts of all those who have contributed to make the convention a very successful one, now therefore be it

Resolved: that the secretary be instructed to write and express the thanks and appreciation of this section to the following: Mr. Rhea Rees; Mr. Joseph S. Nelson, Water Commissioner, and the Personnel of the Sioux Falls Water Department; The Sioux Falls Chamber of Commerce; Mr. R. E. Bragstad, City Engineer of Sioux Falls; The Cataract Hotel; The Carpenter Hotel; Mrs. C. P. Wyman, Chairman of the Ladies' Entertainment Committee; Those responsible for furnishing the lunch on Thursday at the Water Works Plant; The Daily Argus Leader of Sioux Falls.

WHEREAS: The Missouri Valley Section of the American Water Works Association at its Fifteenth Annual Convention has failed to see or hear one Homer V. Knouse of Omaha, Nebraska, and

WHEREAS: most of the members here present declare in loud voices that they never have heard of him, nevertheless his presence has been missed at this convention and it is with regrets that we learn of his indisposition, and therefore, be it

Resolved: that the members of this section express their regrets at his being unable to be with us, and express their wishes for a speedy recovery and look forward to seeing him with us at the Sixteenth Annual Convention, and be it

Resolved: that a copy of these resolutions be forwarded to Mr. Homer V. Knouse of Omaha.

It was moved by Mr. Hinman and seconded by Mr. McAvoy that the report be adopted. Carried. The report of the Nominating Committee was then taken up for action. It was moved and seconded that the Secretary be instructed to cast one ballot for the nominations presented in the report of the Nominating Committee. The motion was carried and the Secretary cast the ballot as directed. Upon a motion made by Thomas Maloney and seconded by J. W. McAvoy, Thomas J. Skinker, Engineer of Distribution, of St. Louis Water Department, was elected as representative director from the Missouri Valley Section on the Board of Directors of the American Water Works Association. Mr. H. V. Pedersen, Chairman of the Auditing Committee, reported that the accounts of the Secretary-Treasurer had been examined and found correct. The report was approved.

The Fifteenth Annual Meeting of the Missouri Valley Section then came to a close by adjourning at 11:45 a.m. on Friday, November 8, 1929. Informal inspection trips, golf and pleasant hunting parties were arranged for Friday afternoon.

A meeting of the Executive Committee of the Missouri Valley Section of the American Water Works Association was called to

order by Chairman Pray at 5:00 p.m. on Wednesday, November 6. There were present Messrs. Pray, Brown, Pedersen, and Waterman. It was moved, seconded and carried that the expenses of the Secretary in connection with the Sioux Falls meeting be paid from Section funds. After some informal discussion of matters in connection with the convention the Executive Committee adjourned.

After the adjournment of the session on Friday morning a meeting of the newly elected Executive Committee was called by Vice-Chairman, H. V. Pedersen. There were present Messrs. Jensen, Brown, and Pedersen. It was moved, seconded and duly carried that Earle L. Waterman be elected Secretary for the ensuing year. The meeting then adjourned.

Earle L. Waterman,
Secretary.

ABSTRACTS OF WATER WORKS LITERATURE[1]

Frank Hannan

Key: American Journal of Public Health, 12: 1, 16, January, 1922. The figure 12 refers to the volume, 1 to the number of the issue, and 16 to the page of the Journal.

Determination of Aluminium as Aluminium Oxide. L. N. Muravlev and O. V. Krasnovskii. J. Chem. Ind. (Moscow), 3: 1146–7, 1926. From Chem. Abst., 22: 2897, August 20, 1928. Blum's procedure (cf. C. A., 10: 1970, 2564), using filter paper pulp to aid in filtration, is recommended.—*R. E. Thompson.*

Service is Best Test of Steel. H. M. Boylston. Iron Age, 121: 1665–8, 1928. From Chem. Abst., 22: 2911, August, 20, 1928. Accelerated corrosion tests are not reliable indicators of service results. Comparative acid tests may give opposite results, depending on kind of acid used. Other variables affecting acid tests also discussed. Service tests alone are conclusive and authoritative.—*R. E. Thompson.*

Structure of Brass Tubing. F. Ostermann. Z. Metallkunde, 20: 186–8, 1928. From Chem. Abst., 22: 2914, August 20, 1928. Surface failures in brass tubing produced by bending were investigated photomicrographically. Desirable grain structure consisting of fine α-mixed crystals with β-residues between grain boundaries is not obtained with less than 61 per cent copper. Copper content of 61 to 61.3 per cent with heat treatment not above 600° is recommended. In zone of pure α-phase (above 63 per cent), danger of coarse crystal structure is too great.—*R. E. Thompson.*

Variations in the Salinity of Estuaries Measured in Situ by Electrical Conductivity. A. Chauchard and (Mme.) Chauchard. Compt. rend., 185: 1503–4, 1927. From Chem. Abst., 22: 3007, August 20, 1928. Modified Kohlrausch conductivity method described for determination from boat of the salinity of water in terms of electric conductivity. Correction must be applied for temperature, but for depths of less than 10 meters, pressure has no appreciable effect.—*R. E. Thompson.*

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[1]Vacancies on the abstracting staff occur from time to time. Members desirous of coöperating in this work are earnestly requested to communicate with the chief abstractor, Frank Hannan, 285 Willow Avenue, Toronto 8, Ontario, Canada.

Sterilizing Water or Other Liquids by Contact with Bodies Coated with Metals such as Copper and Silver. G. A. Krause. Brit. 279,085, October 14, 1926. From Chem. Abst., 22: 2801, August 10, 1928.—*R. E. Thompson.*

The Use of Pinachrome as a One-Color Indicator. I. M. Kolthoff. J. Am. Chem. Soc., 50: 1604–8, 1928. From Chem. Abst., 22: 2894, August 20, 1928. Pinachrome proves to be excellent indicator for range 5.8 to 7.8, e.g., for determining pH of tap or distilled water. Salt error is negligibly small at low concentrations, but with large amounts of electrolyte the pH indicated is a little too low.—*R. E. Thompson.*

Some Factors Involved in Corrosion and Corrosion-Fatigue of Metals. D. J. McAdam, Jr. Proc. Am. Soc. Testing Materials (preprint), 41: 29 pp., 1928. From Chem. Abst., 22: 1915, August 20, 1928. Details given of results of study of simultaneous action of corrosion and alternating stresses on various carbon and alloy steels. If stress is below endurance limit, accelerated corrosion first causes pitting. The stress rises at pits, eventually passing endurance limit. When stress is above endurance limit, fatigue is accelerated by corrosion. Corroding effects of soft water, carbonate water, and Severn River water were investigated. Carbonate water and soft water gave similar results.—R. E. *Thompson.*

Lead in Carbonated Beverages. H. W. Petherick. Ann. Rept. of Pub. Health to June 30, 1927. Great Britain. From Chem. Abst., 22: 2988, August 20, 1928. A study of source of lead in carbonated beverages. Maximum permitted and method of eliminating source given.—*R. E. Thompson.*

Determination of Gases Dissolved in Water. A. De Salles Teixeira. Rev. Brasil. med. farm, 4: 86–9, 1928. From Chem. Abst., 22: 3007, August 20, 1928. Modification of A. Florence's apparatus described, which permits absorption of gases and withdrawal of absorbing solutions without disturbing vacuum. Buret is provided at upper end with stopcock and funnel, closed by stopper with capillary. Lower end is connected with bulb, and latter with flask and mercury container, both connections being made by three-way cocks. Flask of known volume is filled with water, bulb and buret are evacuated and water is boiled out. After total volume of gas is read off, absorbing solutions, in proper sequence, are introduced through upper stopcock —*R. E. Thompson.*

Decreasing Corrosion in the Ice Tank. R. E. Gibbs. Power, 67: 1020–3, 1928. From Chem. Abst., 22: 3005, August 20, 1928. When brine is maintained at pH 7.5 to 8.5 by occasional additions of carbon dioxide, corrosion is at minimum.—*R. E. Thompson.*

Simplified Procedure for Measuring the Index of Water Pollution. Charles Gaussen. Compt. rend. soc. biol., 98: 1405–8, 1928. From Chem. Abst., 22: 3007, August 20, 1928. Test medium is prepared by addition of 30 parts peptone (Poulenc, free from indol) and 5 parts sodium chloride to 1000 of water. After

boiling and filtering, 1 drop of saturated 95 per cent alcoholic solution of toluidine blue is added and mixture sterilized at 115° for 20 minutes. Medium thus prepared is distributed in flasks to which is then added the water to be tested in amounts from 1 drop to 100 cc., and mixtures incubated at 37° for 36 to 48 hours. From color developed the number of B. coli per unit volume is estimated.—*R. E. Thompson.*

Oil Pollution. C. H. Roberts. Conseil Permanent Int. Explor. Mer. J. Conseil, 1: 245–75, 1926; Biol. Abstracts, 1: 790. From Chem. Abst., 22: 3008, August 20, 1928. Gas oil, Diesel oil, 600 seconds oil and 1500 seconds oil were used in experiments, these oils representing 4 types most commonly used at sea. It was found that oil films slow down absorption of oxygen from air, but in very thin films, likely to be met with at sea, slowing down was not appreciable. Agitation, such as at sea, markedly increases rate of absorption through oil films. Simple method is suggested for checking spread of oil fuel in restricted waters. All oils tested were found to be toxic to fish. This is believed to be due to soluble toxic substances and to emulsions. Extracts of gas oil and Diesel oil lose much of their toxicity on exposure to air. Extract of 600 seconds oil was unaffected by exposure and an extract of 1500 seconds oil was rendered more toxic. Oil films do not prevent growth of fresh water plants.—*R. E. Thompson.*

Hydrogen-ion Concentration of the Water of Lake Geneva. W. H. Schopfer. Arch. sci. phys. nat., 8: 22–5, 1926; Biol. Abstracts, 1: 17. From Chem. Abst., 22: 3007, August 20, 1928. Surface readings varied between 7.6 and 7.85; bottom readings between 7.2 and 7.65. Data on other lakes included.—*R. E. Thompson.*

Water Pollution Wastes: Milk-Products Wastes. J. M. Hepler, H. S. Murphy and E. F. Eldridge. Michigan Dept. of Health Pamphlet, 1–15, June, 1927. From Chem. Abst., 22: 3008, August 20, 1928. Preliminary laboratory experiments showed that good floc and efficient settling can be obtained with iron sulfate and caustic soda. At least 0.6 p.p.m. iron sulfate must be employed, or precipitate will be red in color. Lime or caustic soda to produce pH of 7.5 to 8.0 will give good floc, but amount of sludge produced is large. Broad irrigation recommended as temporary expedient where possible.—*R. E. Thompson.*

Water Sterilization by Chlorine. M. Diènert. Tech. sanit. munic., 1928. No. 4, 75–83; cf. C.A., 22: 2629. From Chem. Abst., 22: 3008, August 20, 1928. Dosage employed should vary with organic content, clearness, and degree of contamination. If chlorine-water mixture is agitated for at least 30 minutes, better results are obtained, not because of long-continued action of chlorine, but simply because of good mixing. If water tastes of iodoform, special treatment must be employed. This taste is due to oxychlorides and may result from new pipes. Addition of ammonia often aids in eliminating taste and odor.—*R. E. Thompson.*

Water Supply and Drainage for Industrial Plants. D. D. JACKSON. Proc. Am. Assoc. Textile Chem. Colorists, 1928, 171–8; Am. Dyestuff Rept., 17: 383–90. From Chem. Abst., 22: 3004, August 20, 1928.—*R. E. Thompson.*

Purification of Drinking Waters. E. ROLANTS. Rev. hyg., 50: 373–92; 51: 449–66, 1928. From Chem. Abst., 22: 3007: August 20, 1928. General review of water purification methods and recent researches.—*R. E. Thompson.*

Removal of Manganous Salts from Water. II. Mechanism of Adsorption by Manganese Dioxide. J. TILLMANS, PAUL HIRSCH and HEINZ GROHMANN. Gas u. Wasserfach, 71: 481–7, 1928; cf. C.A., 21: 784. From Chem. Abst., 22: 3008, August 20, 1928. Natural and synthetic manganese dioxide absorbs sodium and barium as well as manganese from solution, but to much slighter extent. No appreciable change in hardness of water is noted in practice. Adsorption of maganese decreases with decreasing water content of the hydrated manganese dioxide and is proportional to surface (for similar material only). Test for adsorptive efficiency has been developed, which depends on catalytic decomposition of hydrogen peroxide. Test may be used for comparing similar material and for following changes in activity of same material during use, but not for material from different sources. **III. Transformation from Manganous to Manganic State After Adsorption.** Ibid., 515–9. Adsorbed manganous manganese may be oxidized to manganic manganese by dissolved oxygen in the water in a purely chemical manner, or by aid of microörganisms, latter being more rapid. Increase in activity of filter in removing manganese is due to formation of hydrated manganese dioxide on surface of filter material. Free carbon dioxide should be low. Manganese-fixing bacteria are harmed by low temperatures, so filter bed should be protected from frost. When iron is present in the water, it should be removed before the manganese. Chlorination should follow removal of manganese.—*R. E. Thompson.*

Precautions Necessary to Prevent Scaling in Heating Plants. H. BALCKE. Gesundh. Ing., 51: 386–90, 1928. From Chem. Abst., 22: 3009, August 20, 1928. Softening with permutit is recommended. Another method is decomposition of carbonates of calcium and magnesium by means of hydrochloric acid. The calcium and magnesium chlorides formed are very soluble and will not cause scale. Photographs of scaling before and after treatment are given.—*R. E. Thompson.*

The Microdetermination of Iodine in Potable Waters. III. The Oxidation Method. MARIO SETTIMJ. Ann. chim. applicata, 18: 104–7, 1928; cf. C.A., 22: 654. From Chem. Abst., 22: 3009, August 20, 1928. Solutions, 0.002 N, of pure iodine and sodium thiosulfate in carbon dioxide-free water were prepared for titration under different conditions to determine source of error in oxidation method of FELLENBERG. Influence of temperature, of concentration and of oxidation with chlorine and sodium hypochlorite were studied individually. When concentration of iodine is not much below 0.002 N, titration with sodium thiosulfate gives satisfactory results at normal room temperatures.

Only when dilution approaches 0.0002 N does temperature have great influence; the farther the temperature from 15° the greater the error. Even at temperature of 15°, however, results are not reliable at dilutions as great as 0.0002 N. Influence of iodine concentration is very small, and if at ordinary temperatures the concentrations of iodine and thiosulfate are not less than 0.002 N, micro-titration gives reliable results. Oxidation with chlorine water by FELLENBERG method, with sodium hypochlorite by BRUBAKER method (cf. C.A., **20**: 3052–3) and with sodium hypochlorite after extraction with ethyl alcohol gave erroneous results, the experiments indicating that reactions were complicated by some unidentified oxidizing agent or other substance.—*R. E. Thompson.*

The New Plant for Removing Oil from Waste Water at the Chemical Factory of C. F. Boehringer and Sons, Mannheim-Waldhof. SCHMEITZNER. Chem.-Ztg., **52**: 388, 1928. From Chem. Absts., **22**: 3009, August 20, 1928. Oil-containing waste waters (50 cubic meters per hour) are led into center of clarifier (cf. WEICKERT, C.A., **21**: 3693) 5 meters in diameter, and then pass radially through clarifying space (15.8 square meters area and 2.9 meters maximum depth, capacity 25 cubic meters) and under peripheral ring to discharge. Separated oil remains within ring and is drawn off periodically by hand. Apparatus is constructed of concrete, and is entirely below ground level.—*R. E. Thompson.*

Engineering Analysis Applied to Municipal Water Works. WM. SHAW. Proc. Eng. Soc. Western Penn., **44**: 47–86, 1928. From Chem. Abst., **22**: 3009, August 20, 1928. Object of this study was to determine which was more economical, (*a*) to expend money for improvements necessary for continued successful operation of present Pittsburgh steam-operated system, or (*b*) to erect new station equipped with electrically-driven units. The necessary calculations are well presented. Although data indicate steam operation to be cheaper, no conclusions are drawn.—*R. E. Thompson.*

Chemical Corrosion of Lead in Soil. O. HAEHNEL. Elektr. Nachr. Techn., **5**: 171, 1928. From Chem. Abst., **22**: 3012, August 20, 1928. Observations given do not check those of American investigators. In general, bare cable sheaths buried in the soil seldom last 25 to 30 years. There is considerable divergence in protective qualities of various pitches and tars used for impregnation.—*R. E. Thompson.*

The Behavior of Trass Cement in Corrosive Waters. H. BACH. Tonind-Ztg., **52**: 1059–60, 1928. From Chem. Abst., **22**: 3029, August 20, 1928. Standard briquets were made from ready-mixed trass cement and immersed in 2.5 per cent magnesium sulfate without any perceptible effect for 3 years. Briquets only partly immersed suffered partial disintegration of half extending into air (due to efflorescent action).—*R. E. Thompson.*

Modern Boiler Problems. A. G. CHRISTIE. Power, **67**: 946–9, 1928. From Chem. Abst., **22**: 3009, August 20, 1928. Discussion.—*R. E. Thompson.*

Boiler Feedwater Treatment in the Southwest. PAUL F. HOOTS. Elec. World, 91: 1340, 1928. From Chem. Abst., 22: 3009, August 20, 1928. Detailed statistical report.—*R. E. Thompson.*

Common Errors and Beliefs Regarding Ground Waters. ALFRED SALMON. L'eau, No. 3, 35–6, 1928. From Chem. Abst., 22: 3009, August 20, 1928. Discussion indicating ease with which ground waters may become polluted.—*R. E. Thompson.*

How Powdered Coal Stands To-day. HENRY KREISINGER. Power, 67: 958–61, 1928. From Chem. Abst., 22: 3032, August 20, 1928. The powdered coal plant is relatively independent of kind of coal and is readily adaptable to changes in demand for steam. Heat liberation at rate of 50,000 B.t.u. per cubic foot of combustion space is probably near maximum and can only be reached under special conditions and with incomplete combustion. Of 75 per cent of ash normally passing out of stack, about $\frac{9}{10}$ can be recovered by electrostatic precipitation.—*R. E. Thompson.*

Pulverized Coal in Stationary Railway Power Plants. I. Power, 67: 1032–6, 1928. From Chem. Abst., 22: 3032, August 20, 1928. Report by sub-committee on "Coal Fired Plants" of International Railway Fuel Association. Without considering powdered coal a panacea, its advantages are: less trouble due to poor coal; flexibility in operation; more rapid and complete combustion; lower banking, standby and low-load losses; higher rating or more boilers per stack; less operating labor; lower maintenance cost. II. Ibid., 1072–5. Pulverizing units, furnace design, and wall construction discussed. III. Ibid., 1118–21. Ash disposal, wall construction, and method of firing discussed. IV. Ibid., 1160–1. Fundamental requirements of ideal unit pulverizer are reliability, efficiency, and low maintenance.—*R. E. Thompson.*

Stable Thiosulfate Solution. L. W. WINKLER. Pharm. Zentralhalle, 69: 369–71, 1928. From Chem. Abst., 22: 3109, September 10, 1928. Addition of 0.1 gram mercuric cyanide per liter to 0.1 and 0.01 N solutions of sodium thiosulfate serves to stabilize this reagent by keeping solutions sterile.—*R. E. Thompson.*

Disposal of Waste Crank-Case Oil at Garages. Eng. News-Rec., 102: 306–7, February 21, 1929. Data given from mimeographed report by BRUNOR E. LUNDY on disposal of crank-case oil in District of Columbia. As result of survey it is recommended that garages, etc., be required to provide approved containers or underground tanks, separate and apart from garage traps, for retention of all waste crank-case oil; contents of same to be removed by occupant or operator at regular intervals or upon notice from district authorities. It is proposed that contract be made under competitive bidding for collection, transportation, and disposal of such wastes, service to be guaranteed by proper bond and regulated by direct supervision of district government. In view of fact that re-refined oil has been determined usuable and valuable, it is expected that this service will be without cost to either district or public, contractor

realizing his earnings from ownership of oil collected. Methods of utilization at present practised include: as aid to incineration of refuse; oiling of roads; manufacture of paint; and re-refining, Bureau of Standards having shown that product of latter may be as good or even better than original oil. Intercepting traps have not been found an effective remedy. Abstracts included of replies received to inquiry sent to American and foreign cities relative to experience in regard to these wastes. Tabulation given in original of data contained in 46 replies to questionnaire regarding disposal of waste oil in American cities.—*R. E. Thompson.*

Good Practice in High Dams. REGINALD RYVES. Eng. News-Rec., 102: 324, February 21, 1929. Brief discussion of thrust buttress type of multiple arch dam designed by RYVES. Attempted combination of weight-moment principle with thrust principle in lower part of dams produces bastard type, the stresses in which are relatively high.—*R. E. Thompson.*

The Nature of Plankton and its Influence on Water Supplies. E. S. STOKES. Proc. First Commonwealth Conference on Public Health Engineering, Dept. of Health, Melbourne, Australia. A popular presentation of the problem of plankton in public water supplies. Presents much technical information in form available to non-technical reader interested in the control and maintenance of water supply systems.—*A. W. Blohm (Courtesy U. S. P. H. Eng. Abstracts).*

The Action of Active Chlorine on Aquatic Plants. K. GEMEINHARDT. Kl. Mitt. Ver. Vasserversorg. Abwasserbeseitg. 2, 124–30; Chem. Zentr. 1927, II, 1743. Chemical Abstracts, 23: 9, 2231, May 10, 1929. The introduction of strongly chlorinated waste water into streams causes damage to the vegetation and microörganisms, if the water contains more than 15 mgm. Cl per litre. For removing undesirable vegetation in water reservoirs of technical water, cooling towers, etc., about 100 mgm. Cl per litre may be added to the water during a working pause and allowed to act as long as possible. Mechanical removal of the dead vegetable matter should bring relief from the nuisance for some time.—*A. W. Blohm (Courtesy U. S. P. H. Eng. Abstracts).*

The Water of Several Hungarian City Aqueducts, Wells and Bathing Places near Lake Balaton and that of Several Railroad Stations. I. SZANYI. Kiserl. Kozl. 31, 1–20 (1928). Chemical Abstracts, 23: 9, 2231, May 10, 1929. Water of city aqueducts was proved to be good; 52.8 percent of the examined railroad-station wells and 37.5 percent of bathing place wells was found drinkable. The amount of water produced in cities with aqueducts varies from 29.7 to 182.5 l. to the person daily. Aqueducts should be established, if possible since ordinary wells yield good drinking water only in case of frequent cleanings.—*A. W. Blohm (Courtesy U. S. P. H. Eng. Abstracts).*

Cleansing Rough Filters. **(Het Schoonmaken van Voor-filters.)** P. JONGEPIER. Water en Gas, November 30, 1928, p. 230. Water and Water Engineering, 31: 362, 92, February 20, 1929. In cleansing gravel filters by the usual

method of reversed flushing, raking the top layer, and playing on it with a hose, only the upper 15 cm. of gravel are cleansed, and the gravel below to a depth of some 40 cm. eventually becomes very foul and almost impenetrable. A new device consists of a tapering nose piece 25 cm. long for attachment to a hose pipe. The piece is bored with four rows of small holes, set at 45 degrees in a backward direction, and one hole at the apex, and is made of bronze to withstand wearing by the gravel. When this piece is introduced into the gravel it automatically burrows in, and being repeatedly applied at small distances, gives effectual cleansing of the deeper layers, with a great saving of time and labor.—*A. W. Blohm* (*Courtesy U. S. P. H. Eng. Abstracts*).

Brantford Water Supply Report. Anon. Canadian Engineer, 56: 1, 104, January, 1929. The present filtration system is absolutely ineffective as regards improving the bacterial quality of the water and, as a result, a large amount of chlorine must be applied to the water. The bulk of the water at present supplied is derived from the extension put in last year. All the old filtration galleries are now useless and the 1922 extension has just about reached the limit of its usefulness. The only solution to the problem is the construction of a filtration plant. The installation of efficient pumping equipment is also recommended.—*A. W. Blohm* (*Courtesy U. S. P. H. Eng. Abstracts*).

A Century of the Pittsburgh Water Works. E. E. Lanpher. Proc. Eng. Soc. Western Pennsylvania, 44: 10, 331, January, 1929. Interesting description of gradual growth of Pittsburgh's water works from 1828, when one steam pump, 1½ miles of pipe and one reservoir served about 10,000 residents of a ½ square mile area, to the present works serving a population of 590,000 in the area of 37 square miles. Although filtration was first recommended in 1847, it required a lapse of 60 years for filtration to become a reality.—*A. W. Blohm* (*Courtesy U. S. P. H. Eng. Abstracts*).

State Board of Health of Kentucky Swimming Pool Regulations. Anon. Jour. Amer. Assoc. Promoting Hygiene and Public Baths, 10, 1928. Excess chlorine limits shall be 0.2 to 0.5 p.p.m. when chlorine compounds are used. When alum is used water shall test alkaline. Water shall be clear enough to show a 6-inch disc at deepest point from a distance of ten yards. Water should not be heated to over 72°F. Air must not be over 8° warmer, nor 2° colder than the water. Bacterial requirements are somewhat more lenient than for drinking water. Visible dirt or scum shall not remain over 24 hours. Not over 20 persons shall bathe for each 1000 gallons of clean (new or refiltered) water added during any period of time. Not over seven persons per 1000 gallons of water in the pool shall bathe between disinfections of pool where disinfection is not continuous.—*A. W. Blohm* (*Courtesy U. S. P. H. Eng. Abstracts*).

Water Sterilization by Chlorine Gas. (Chem. Age. 1928, 19, 167). Dept. of Scientific and Industrial Research, Water Pollution Research Board, Summary of Current Literature, 2: 1, A-6, November, 1928. A description of the method

of purifying the water at the Guilford swimming bath, which has a capacity of 50,000 gallons. The whole contents of the bath are circulated through the filtration and purification plant every four hours, i.e. at a rate of 12,500 gallons per hour. The treatment is as follows: straining, treatment with aluminum sulphate and soda ash, filtration through Paterson rapid sand filters, aeration and continuous chlorination by the Paterson "Chloronome" apparatus, using about 0.5 p.p.m.—*A. W. Blohm (Courtesy U. S. P. H. Eng. Abstracts).*

The Baltimore (Md.) City Health Department Method of Supervising Pools. Anon. Jour. Amer. Assoc. for Promoting Hygiene and Public Baths, 10, 1928. A statement of standards promulgated includes under equipment: Walkway drains; ventilation and sunlight; dressing rooms; pre-cleansing baths and shower rooms; toilets; general layout; and under management: Condition of water ("there should be an excess of the disinfectant at all times"); suits and towels; barring of the diseased or bandaged, and spitting prohibitions; bathing load; posters; records; temperature and alkalinity. A score card is given with the system of rating.—*A. W. Blohm (Courtesy U. S. P. H. Eng. Abstracts).*

New York State Department of Health Swimming Pool Regulations. Anon. Jour. Amer. Assoc. for Promoting Hygiene and Public Baths, 10, 1928. The regulations effective May 15, 1928, cover: Definitions; permit and revocation; construction and maintenance; circulation; dressing rooms; toilets; shower baths; sanitary quality of pool water; bathing load limits; operator or attendant and operating records; care of suits and towels; attendant; pre-pool shower; pollution of pool prohibited; communicable disease; spectators; posting regulations. Under the above headings is included a requirement that not more than 10 pecrent of samples covering any three months' period shall contain more than 500 bacteria per cubic centimeter 37°C., that not more than two out of five 1 cc. samples collected in the same day, or not more than three out of any ten consecutive 1 cc. samples of the water used shall indicate *B. coli*, that these bacterial requirements may be ignored where excess chlorine is maintained at 0.2 p.p.m. or more, that not over 20 shall bathe for each 1000 gallons of clean water (new or re-purified) added during any period, that not over seven shall bathe for each 1000 gallons of water in the pool between successive disinfections where disinfection is not continuous, that an operator shall keep records, and that the regulations shall apply to indoor and outdoor, and to artificial and partly artificial pools, the last to mean a pool formed from a natural body of water which has either so limited a flow or such an inadequate natural circulation that the quality of water must be maintained by artificial means.—*A. W. Blohm (Courtesy U. S. P. H. Eng. Abstracts).*

On the Intestinal Bacteria of Fishes from the Standpoint of the Hygienic Estimation of Drinking Water. (Minkewitsch, I. E., u. Trofimnk, N. A.; Zeit., f. Hyg. u. Infektkr., 1928, CIX, 39.) Abstracts of Current Public Health Literature (issued by Dept. of Pensions and National Health, Ottawa, Canada) February, 1929. This contribution from the Hygienic Institute of Leningrad again reviews the question of the importance of coliform bacilli found in the intestines of fishes, largely upon the results of the Eijkman-Bulir test,

wherein the material examined is grown in a 2 percent glucose peptone solution at 46°C. As a result of their investigations, the authors believe that the intestinal tracts of fish are inimical to the growth of genuine B. coli from warm blooded sources, even when the fish are taken from polluted waters, and that the Eijkman test in the light of their results is unreliable. A reviewer points out that their conclusions as to the unreliability of the Eijkman test is unjustified, inasmuch as they did not carry out the test on their fishes according to the Eijkman technic.—*A. W. Blohm* (*Courtesy U. S. P. H. Eng. Abstracts*).

Municipal Engineering in 1928. Anon. Surveyor, **75**: 1931, 69, January 25, 1929. Water Supply. Increasing uses of water are demanding provision for higher per capita consumption than 20 to 30 gallons previously necessary. The trend toward purified river supplies must therefore be more pronounced because of the inadequacy of upland or underground sources. Water purification processes and control of pollution of streams by sewage and trades wastes are therefore becoming increasingly important. Other subjects reviewed include the life of water mains, the increasing demand for adequate and safe rural water supplies, new water works construction, the treatment and use of river water, chlorination, the relation of impure water to disease, location of underground sources by the divining rod, and cleansing of water mains. Outstanding papers on many water supply subjects are mentioned.—*A. W. Blohm* (*Courtesy U. S. P. H. Eng. Abstracts*).

Dangers from Public Swimming Pools. Anon. Jour. Amer. Medical Assoc., **91**: 22, 1831, December 1, 1928. Attention is invited in this very brief article to the condition of swimming pools in Paris, France. There are said to be swimming pools that are used by from 1200 to 1400 persons per day, which contain only 700 cubic meters of river water renewed once a week. There is no close supervision over the pools and the danger of bathers contracting certain diseases is pointed out in this article.—*A. W. Blohm* (*Courtesy U. S. P. H. Eng. Abstracts*).

Lead Poisoning from Lead Piped Water Supplies. Wade Wright, Clarence O. Sappington and Eleanor Rantoul. Jour. Indust. Hygiene, **10**: 7, 234, September, 1928. There are many cases of lead poisoning which cannot be traced to occupational exposure to lead but which are due rather to the use of water supplied through lead pipes. Of the cases of lead poisoning s udied over a period of many years (1911 to 1928) in the Industrial Clinic of the Massachusetts General Hospital, it was found that almost 11 per cent of them were of non-industrial origin, for the most part associated with the consumption of lead piped waters, of home distilled alcohol, or of homemade wines, this group being, in size, second only to that of painters. A brief study of the matter was carried on in eastern and central Massachusetts during the summer of 1923. One hundred and two sources of water supply were investigated and data regarding 253 persons were obtained, the economic status of those persons varying greatly. A group of 63 cases of definite or very probable poisoning was selected for the purpose of tabulation and comparison. Forty-two of the 63 cases of poisoning were related to the use of water supplies which each pro-

duced two or more cases of poisoning. Eight of the remaining 21 cases were users of sources in connection with which but a single clinical observation was made. "One source, a spring supplying a private school, produced eleven cases among twenty-four persons exposed; another spring, five cases among thirteen persons exposed." It was concluded that spring waters are more hazardous than well waters, and these in turn more dangerous than the city and town supplies. "All the waters analyzed contained lead." "The lead content was most strikingly related to the carbon dioxide content." "There was no apparent relation between length of pipe and lead content." "Poisoning occurred among fourteen persons ingesting as little as 0.1 mgm. of lead daily, over an average period of eight and one-quarters years." "The incidence of poisoning was quite uniform among those ingesting varying amounts less than 1.5 mgm. daily but was much greater as this amount was exceeded." "The duration of exposure does not seem to be a factor of great importance in the production of poisoning, as a greater incidence was found among those exposed from three to five years than among those exposed over ten years."—*A. W. Blohm (Courtesy U. S. P. H. Eng. Abstracts).*

Report of an Epidemic of Dysentery. W. D. DAVIS. U. S. Naval Medical Bulletin, 27: 2, 382, April, 1929. The mortality resulting from an epidemic of bacillary dysentery occurring on the Naval Reservation at Olongapo, P. I., was 30.26 per cent and all deaths were of children under eight years of age. Olongapo has a population of 6000 and is only a few feet above the sea level. At high tide most of the streets are covered with water. The houses are not equipped with toilets, but public toilets are maintained at the end of short cross town streets. The streets have open drains which are flushed once a week. During high tide, water backs up into this drainage system, and the wind carries the spray from the running sewers to the houses along the beach. The water supply is secured from an impounded reservoir untreated. The watershed is patrolled.—*A. W. Blohm (Courtesy U. S. P. H. Eng. Abstracts).*

Removal of Tastes and Odors from Filtered Water by an Economical Method of Aëration. Brit. Waterworks Ass. Off. Circ., 1929, 11: 137; Surveyor, October 14, 1927, 352. Treatment of water supplies may effect purification without entirely removing taste and odor. At four New York plants, the filtered water is aërated by spray nozzles attached to the effluent pipes from the filters. In its fall from the filter to the clear-water well, gases productive of taste and odor, as well as carbon dioxide, are greatly reduced. At Providence, N. Y., 20 m.g. per day are treated by a first aëration after adding coagulant and a second, by means of the effluent aërator described above. At Poughkeepsie, the effluent aërator is installed between the mechanical filters and the sand filters.—*M. H. Coblentz, (Courtesy of the Department of Scientific and Industrial Research, Water Pollution Research Board, Summary of Current Literature).*

Determination of Manganese in Water. J. DE GRAAF. Chem. Weekblad, 1929, 26: 103. J. Soc. Chem. Ind., 1929, 48: B, 266. The sample is boiled with nitric acid, heated with a small excess of silver nitrate, and boiled with ammonium persulphate until clear. The permanganate formed is determined colori-

metrically without filtering. Manganese compounds settle out on the walls of the vessel if the sample is kept for some time.—*M. H. Coblentz* (*Courtesy of the Department of Scientific and Industrial Research, Water Pollution Research Board, Summary of Current Literature*).

The Bacteriophage in the Water of the River Don at Rostow. D. Bujanowski. Zentralbl. f. Bakt., **110**: 120, 1929. Experiments were undertaken to discover the cause of the bactericidal property of the Don water. One hundred-cc. samples of the water were inoculated with four pathogenic bacteria, typhoid, paratyphoid A and B, *B. coli*, and paracoli. After 6 days, agar plates were inoculated with the water samples and the number of bacterial colonies which developed in 48 hours were counted. The paracoli were the only bacteria to develop from the river water, while in parallel experiments with sterilized river water all four bacteria developed many colonies. The experiment was repeated with river water, which had been passed through a Chamberland candle filter to remove all the water bacteria. The same results were obtained showing that the pathogenic bacteria were not destroyed in competing for a livelihood with the water bacteria. During May, at the time of high water, however, the river water lost its bactericidal property. Later this was considered to be due to the fact that the greater part of the highwater is surface water, which would contain no bacteriophage. In the sterilized river water the typhoid bacteria were found not only to survive but to multiply rapidly. River water, heated for 24 hours at 37°C. and passed through a Chamberland candle filter, was used to examine the nature of the bacteriophage which was assumed to be the cause of the bactericidal properties of the Don water. It showed the usual bacteriophagic properties; sterile spots and half-moon scraggy shaped ("Flatterformen") colonies of paratyphus A on agar plates and was also found to be capable of dissolving bacteria.—*M. H. Coblentz* (*Courtesy of the Department of Scientific and Industrial Research, Water Pollution Research Board, Summary of Current Literature*).

Report on the Crustacea Copepoda. R. Gurney. Trans. Zool., 1927. Part 4. Intern. Rev. ges. Hydrobiol. u. Hydrograph., **21**: 274, 1929. This report deals with the discoveries made on the Cambridge Expedition to the Suez Canal. Detailed descriptions of the Copepoda, especially littoral and semi-parasitic species, found on this occasion are given and a general survey of the classification and geographical distribution of the whole group is made.—*M. H. Coblentz* (*Courtesy of the Department of Scientific and Industrial Research, Water Pollution Research Board, Summary of Current Literature.*

Recent Advances in Public Health Bacteriology and their Bearing on Water Analysis and on the Epidemiology of Typhoid Fever. W. J. Wilson. Brit. W. W. Ass. Annual Meeting: Brit. Waterworks Ass. Off. Circ., **11**: 34, 1929. The sanitary condition of water is not in practice estimated by identification of pathogenic organisms, but by bacteria of faecal origin always associated with them, notably *B. coli*, streptococci, and *B. Welchii*. *B. coli* is in this country cultivated on McConkey's bile-salt lactose neutral red medium, and in America in lactose broth, with or without bile salt and dyestuffs, particu-

larly brilliant green. Good agreement is found between the methods. Excretal *B. coli* are distinguished from certain strains of vegetable origin, and from allied organisms, such as *B. lactis aërogenes*, by cultivating them in selective media. True faecal *B. coli* conform to HOUSTON's well-known "flaginac" classification. Opinion is divided on the subject of the viability of organisms of the *B. lactis aërogenes* type, which has an obvious bearing on their usefulness as an index of recent pollution. The occurrence of this type is not necessarily indicative of a comparatively safe water, its ratio with respect to *B. coli* in polluted, unpolluted, and stored waters appearing to be constant. The author has found the methyl-red, VOGES-PROSKAUER, and uric acid-sodium citrate reactions very useful in judging the safety of waters; and the discovery by KOSER that cellobiose is fermented by *B. lactis aërogenes* and not by excretal *B. coli* may render further assistance. Generally the presence in numbers of non-excretal types in well waters shows ingress of undesirable surface water. *B. Welchii* can be identified by reduction of sodium sulphite in media containing glucose and an iron salt. *B. coli* forms colonies in such media, but may be destroyed by preliminary heating if present in such numbers as to arrest the growth of *B. Welchii*, which persist by reason of being in the spore form. The large black colonies of *B. Welchii* should not exceed 2 in 40 cc. of water: the accompanying smaller colonies, due to intestinal anaërobes or saphrophytic organisms, should not occur in large numbers. *B. typhosus* may be cultivated in a bismuth sulphite medium; details of this and of the iron media are given. No accurate information is available on the viabilikly of *B. typhosus* in effluents from typical sewage treatment plant. Experience suggests that the organism disappears fairly quickly from the liquid, settling in the deposit, where, however, it does not multiply; aëration seems to promote its destruction. As this organism has been detected in the excrement of seagulls, it is important that gulls shall be excluded from the clear water basins of water works; crossed wires 1 foot above the water have achieved this object in San Francisco. The action of carriers in disseminating typhoid fever is discussed in connection with the theories of MURCHISON and of BUDD last century, and the high incidence of *B. typhosus* in Belfast sewage attributed to an unusual proportion of carriers in that city. Most organisms harboured by carriers are not virulent, and only become so in certain circumstances. A comprehensive list of references concludes the paper.—*M. H. Coblentz* (*Courtesy of the Department of Scientific and Industrial Research, Water Pollution Research Board, Summary of Current Literature*).

Data on Rapid Sand Filtration Plants. T. C. HERSEY. Canadian Eng., 56: 337, 1929. In modern practice rectangular units of concrete are replacing circular units of wood or steel. It is suggested that standard units should be 15 by 12 feet and 8 feet deep, and capable of dealing with 500,000 gallons per day. If these sizes are adopted it is easy to obtain suitable underdrains and wash-water troughs etc., while the depth permits the employment of a four-foot bed of gravel and sand and up to four feet head of water when the plant is in operation. The gravel bed is now recognized as the important factor in the efficient collection of the filtered water, the proper distribution of wash-water and the prevention of sand losses. This bed should be carefully graded in

layers 3 to 4 inches thick and varying in size from 2½ inches to $\frac{1}{16}$ inch. The sand bed resting thereon should be composed of the largest size of sand grain which is compatible with efficient filtration, a useful size being between 0.40 and 0.50 mm. with a uniformity coefficient not exceeding 1.7. The sand should have a high specific gravity and be as free as possible from perishable substance, e.g. lime. The wash water troughs should be of ample capacity, set parallel and absolutely level, with all the sills in the same horizontal plane and approximately 3 feet 6 inches apart. The height of the sills above the sand bed depends on the character of the sand and the rate of applying the wash water, two feet being an average distance. The usual rate of operation of a sand filter is about two gallons per square foot per minute, but this is subject to variation according to the character of the influent and the quality of effluent required. Immediately the choking of the medium is indicated by a decrease in output, the flow should be reversed and the filter washed. Hydraulically operated valves are recommended when the plant is of sufficiently large size to justify their cost.—*M. H. Coblentz* (*Courtesy of the Department of Scientific and Industrial Research, Water Pollution Research Board, Summary of Current Literature*).

Experimental Filtration Plant at Ottawa. Canadian Eng., 56: 359, 1929. In order to obtain data with regard to the purification of Ottawa River water for potable purposes, a large-scale experimental plant has been installed, the results of which will define the characteristics of the permanent plant to be constructed at an estimated cost of $1,315,000. The filters, coagulating basins, etc., occupy 35 feet 8 inches by 12 feet by 11 feet high and, at present, are dealing with a flow of 2,000 gallons per hour. The installation is in duplicate, so that one set may be operated as a control while the effect of varying any particular factor in the other set is being determined. It is hoped in this way to obtain substantial economies with the full-scale plant.—*M. H. Coblentz* (*Courtesy of the Department of Scientific and Industrial Research, Water Pollution Research Board, Summary of Current Literature*).

Sterilization of New Water Mains. E. C. Sullivan. Canadian Eng., 56: 371, 1929. Pollution of water mains when being laid is almost inevitable. Sterilization may be effected by means of a small solution feed chlorinator or by introducing chlorine gas from cylinders into sections carrying water at a minimum pressure. The gas is passed in until a strong *ortho*-tolidine reaction is given at the other end of the section, when the section is closed and the heavily chlorinated water left to stand in the main for several hours. The main is then opened and flushed free from chlorine. Calcium hypochlorite may be used by placing about one ounce in each length of pipe when laying, filling the section with water, and leaving overnight; followed by a thorough flushing. It is also necessary to test with *o*-tolidine for an excess of chlorine when using this method. A bacteriological examination is especially advisable when using the latter method as chlorine from the hypochlorite will sterilize only the top layer of any mud that may have accumulated. Mud accumulations must be removed by successive flushings. Sterilization by chlorine gas has the advantage over treatment with calcium hypochlorite in this respect

and in its greater flexibility of application.—*M. H. Coblentz (Courtesy of the Department of Scientific and Industrial Research, Water Pollution Research Board, Summary of Current Literature).*

Water Supply at St. Catherines, Ont. Canadian Eng., 56: 332, 1929. The raw water is drawn from the Welland Canal and is coagulated, filtered, and chlorinated prior to distribution. A bacterial removal of 90 to 98 percent is said to be obtained by the filters and 100 percent after chlorination. The amount of aluminium sulphate used varied from 0.45 to 1.15 with an average of 0.64 grain per gallon and the chlorine dosage was 2.1 pounds per million gallons. The total volume pumped during the past year amounted to 1,733,-300,000 gallons of which 4 percent was used in back-washing filters, etc. The daily amount supplied was equivalent to 115 gallons per head, about one-third of the supply being metered. It is considered economical prior to the paving of streets to replace existing iron pipe with copper, in the hope of a later saving in maintenance and renewal costs.—*M. H. Coblentz (Courtesy of the Department of Scientific and Industrial Research, Water Pollution Research Board, Summary of Current Literature).*

Extraction of Phenols from Coke Plant Effluents. Official News of the "Emschergenossenschaft" for April, 1927, to March, 1928; Gas- u. Wasserfach, 72: 275, 1929. Experiments on the recovery of phenols from coke plant liquors by the Emscher Company, show that the liquor must contain at least 2 grams phenol per litre to make the process profitable. It is possible to remove all the phenol except 0.6 to 0.8 grams per litre. Twenty to twenty-five percent of benzol is used as a washing reagent and can be recovered, either in a benzol scrubber after the liquor has passed through the ammonia still, or directly in a special still included in the phenol recovery plant. About 5000 tons phenol yearly could be recovered by the coke plants in the Emscher district. The market for raw phenol oil is increasing.—*M. H. Coblentz (Courtesy of the Department of Scientific and Industrial Research, Water Pollution Research Board, Summary of Current Literature).*

The Purification of and Recovery of Substances from Waste Waters. Metallges. Akt. Ges., Frankfort-on-Main, Germany, E. P. 305,657. Patents Official Journal, No. 2098, 1040, 1929. Aqueous liquids, particularly waste waters from coking plants, cellulose and other factories, can be clarified by active carbon or other adsorbent material and the adsorbed substances can be subsequently recovered with a solvent, preferably one which is insoluble or sparingly soluble in water. The liquid under treatment may be passed in one direction and the solvent in the opposite direction and a number of containers connected on the counter current principle may be used. Benzol, carbon disulphide, and mixtures of benzol with alcohol or acetone are suitable solvents. Phenol is recovered from coking plant effluents by means of active carbon and benzol. The phenol is separated from the benzol by distillation.—*M. H. Coblentz (Courtesy of the Department of Scientific and Industrial Research, Water Pollution Research Board, Summary of Current Literature).*

Studies in Colloid Chemistry in the System-Colloidal Ferric Hydroxide, Hydrochloric Acid, Water. Preliminary Communication. E. Heymann. Kolloid-Zeitschrift, 47: 48, 1929. The change which occurs in a solution of ferric chloride has been attributed to slow hydrolysis leading to true equilibrium. Simultaneously hydrochloric acid is adsorbed by the colloidal particles. Considering the equilibrium as sharply heterogeneous with ferric hydroxide as the dispersed phase, the ratio $[HCl]^3/[FeCl_3]$ should be constant. Experiments show variation up to 30 per cent according to the amount of hydroxide present, so that its active mass is not constant. Further the size of particle of ferric hydroxide affects the position of equilibrium. Equilibrium mixtures derived from solutions of ferric chloride contain more chlorine on the hydroxide particles than mixtures of equivalent quantities of ferric hydroxide sol and hydrochloric acid. Numerous experiments show that the addition of ferric hydroxide sol to a solution of ferric chloride greatly increases the speed of hydrolysis. Full consideration of the results obtained will be given in an early paper.—*M. H. Coblentz (Courtesy of the Department of Scientific and Industrial Research, Water Pollution Research Board, Summary of Current Literature).*

Use of Dye in Underground Leakage Survey. Anon. Municipal News and Water Works, 76: 86, 1929. The ordinary methods of determining leakage could not be used in South Chicago where the water mains are at depths to 12 feet below the street level. By the dye method the section of the main to be examined is isolated and fuchsine under pressure passed into the pipe at the by-passed valve. The rate in feet per second at which the dye-colored water in the main is moving is calculated from the cross section of the main and the volume of water being recorded by the master meter. After this is done the first house meter is disconnected and water is drawn off in a volume equal to the contents of the service pipe. If the dye has reached this point in the computed time the water is shut off on the service pipe and the next service pipe opened and similarly tested. This is continued until the point is reached where the dye does not come through the service pipe in the computed time. Then the uncolored water is drawn off and its volume measured. The distance from the service pipe under test to the leak is determined from the volume of the water and the cross section of the pipe.—*C. C. Ruchhoft (Courtesy Chem. Abst.).*

Meter Accounting and Reading by the Water Department of Detroit. Municipal News and Water Works, 76: 1161–2, 929. The system is described by which 250,000 meters are read. The city is divided into 36 districts, each having about 7000 meters. Each district is read every 3 months. Check up is made of meters not read, broken meters, etc. Bills are delivered 15 days after meter readings. Special methods are used in estimating consumption when readings cannot be made. Where particularly high amounts of water are used, meters are read monthly and assessed on the flat rate, or on numbers of openings and purpose for which water is used. Special assessment is made in cases of temporary water service.—*C. C. Ruchhoft (Courtesy Chem. Abst.).*

Chlorination of Deep Well Water. M. F. Trice. Municipal News and Water Works, 76: 153, 1929. The Siler City, N. C., water supply having

developed objectionable taste and odor during spring seasons, flushing of mains was resorted to, but proved to be ineffective. The condition of the water was found to be due to the presence of iron bacteria. The entire main system was finally saturated with chlorine. Within a week the water was entirely cleared of offensive taste and odor.—*C. C. Ruchhoft (Courtesy Chem. Abst.)*.

Municipal Swimming Pools. A. M. Crane. Municipal News and Water Works, 76: 85–6, 1929. The growth of swimming pools in number and in size is discussed. It is recommended that both wading and swimming pools should be considered on the same basis as far as purity of water is concerned. The water purity should be maintained by refiltration and disinfection unless there is a constant flow of pure water.—*C. C. Ruchhoft (Courtesy Chem. Abst.)*.

The Albany, New York, Typhoid Fever Damage Suits. Anon. Municipal News and Water Works, 76: 35, 1929. The appellate division of the Supreme Court of New York upheld the action of a supreme court jury which in November, 1926, awarded $2000 to a minor and $1000 to his father on the claim that the patient contracted typhoid fever from the drinking water of the city.—*C. C. Ruchhoft (Courtesy Chem. Abst.)*.

Cleaning a Water Main. G. E. Shaw. Municipal News and Water Works, 76: 58, 1929. A 14-inch water main 1¾ miles long had become choked up to a depth of about 2½ inches with a soft chalky deposit. Hatchboxes and washout valves were installed at two points and the entire length of the main cleaned and flushed out by forcing through it blocks of ice 14 inches in diameter and 4 feet long. The ice blocks traveled a 3000-foot section in ten minutes. The entire cleaning and flushing operation required only 2½ hours and it was estimated that 26 cartloads of the deposit were discharged from the main.—*C. C. Ruchhoft.*

Water Works Records. Clarence W. Wright. Municipal News and Water Works, 76: 87–8, 1929. The city of Detroit divides all pipe laying work into 4 classes. Class A jobs are those recommended by the department and include the laying of mains above 16 inches, replacement, the lowering of mains where necessary in streets to be paved, and mains for better fire protection. All jobs ordered upon the petition of a property owner inside the city limits are known as Class B jobs. The Class C jobs include work on mains laid outside the city limits. The village or subdivision must submit plans for such work and after they are approved a city inspector is placed on the job to protect the department as to workmanship and depth of pipe. Class D includes all jobs where the work is to be billed to outside organizations. Sketches are made in the field of all pipe laid, lowered, or discontinued.—*C. C. Ruchhoft.*

Significance and Methods for Determination of Filter Plant Turbidities. John R. Baylis. Municipal News and Water Works, 76: 156–9, 1929. While filtration does not remove bacteria in direct proportion to turbidity, the tur-

bidity removal can be used as an approximate index of bacterial removal. Such indices may not be very accurate, but turbidity can be read immediately and has that advantage over bacterial counts. If the turbidity, in place of being reduced to 1.0 p.p.m., is reduced to 0.2, this produces an additional 5 to 8 percent removal of bacteria and is worth while in polluted waters. Three instruments that were developed for measuring and controlling turbidity removal are described. The first is a submarine light which is placed near the bottom of the clear water reservoir. This light when under 6 feet or more of water will show turbidities of 0.2 p.p.m., but will not enable the operator to determine whether the filters need washing or more chemicals are needed. A floc detector which is installed on the filter operating tables was developed to determine when flocculated matter is passing the filter and washing is required. The floc detector consists, briefly, of a two-liter flask arranged for a continuous flow of filtered water through it and enclosed in a dark container in which the light from a 250 watt lamp is directed through the flask at right angles to the axis of observation. This arrangement will not show fine turbidities. A turbidimeter developed for reading low fine turbidities of from 0.1 to 0.2 p.p.m., obtained when the water is slightly undertreated, is illustrated. The procedure recommended in practice is to determine the total turbidity with the special turbidimeter and the floc turbidity with the floc detector. The fine turbidity is obtained by subtracting the floc turbidity from the total turbidity and arbitrary limits of 0.2 for fine and 0.05 for floc turbidity are suggested. When the floc turbidity exceeds 0.05, the filters should be washed more often and when the fine turbidity exceeds 0.2, the coagulant should be increased.—*C. C. Ruchhoft* (*Courtesy Chem. Abst.*).

The Experimental Filtration Plant of Chicago, Illinois. JOHN R. BAYLIS. Municipal News and Water Works 76: 89–95, 1929. This plant was constructed for the purpose of determining the cheapest and most efficient treatment for Chicago. It is desired to produce a water averaging not more than one-tenth of the number of *B. coli* allowed by the Treasury Department on common carriers and with an average turbidity of not over 0.2 p.p.m. The plant is housed in an attractive stuccoed frame building and its main parts are built of reinforced concrete or steel. The plant was designed to conduct experiments with only one variable. Its main features are: 1. A balancing tank to maintain a uniform head on the control valves. 2. Four chemical solution tanks and a dry feed machine. 3. Three mixing basins. One with horizontal conduits, one with vertical conduits, and one with mechanical agitation. 4. Two settling basins and one small settling tank. 5. Twelve filters. Two with a surface area of 100 square feet each and the other ten, with 10 square feet each. 6. Two clear water reservoirs. 7. One wash water tank. 8. Two wash water pumps. 9. Two chlorinating machines. 10. Carbon dioxide generating plant. 11. Chemical laboratory. 12. Bacteriological laboratory. Mechanical mixing will be used for most of the experiments. The mechanical mixing basin is divided so that the water may be divided for two different treatments. Interchangeable gears are provided which allow a wide variation in the speed of the stirrers. The horizontal mixing chamber has 50 conduits

each about 10 inches square and 30 feet long and has a number of take-offs for varying the mixing time. This chamber has a 25-minute mixing period at a velocity of 1 foot per second. The over-and-under mixing basin has 81 conduits, each 12 inches square and 11 feet 3 inches long, and provides for a total mixing time of 15.2 minutes at 1 foot per second. It also has a number of take-offs. The two settling basins have two compartments each. Each compartment is 7 feet wide, 30 feet long, 12 feet deep at one end and 10.5 feet at the other. It is not expected that much will be learned about the design of large settling basins from these small ones. The two larger filters are of standard design and are equipped with rate-of-flow and loss-of-head gauges. They are equipped with an unusual surface washing system consisting of $\frac{3}{4}$-inch pipes spaced 20 inches apart and about 1 foot above the sand. The pipes have $\frac{1}{16}$-inch holes spaced 12 inches apart to project water downward at 30 degrees to the horizontal. No additional wash water is used by this system but about one-fifth of it is applied through the upper system of piping at a higher pressure than that applied beneath the bed. The ten small filters are built of steel and are movable. These filters are provided with hose connections so that changes in set up can be made by the operators. The rates of flow in the small filters are set by hand and are adjusted every hour. The experimental work has been divided into 44 subjects and work is under way on 23 subjects. This work includes various subdivisions under each of the following heads: 1. Chemical treatment. 2. Mixing basins. 3. Settling basins. 4. Filters. 5. Chlorination. 6. Removal of tastes and odors. 7. Filtration without chemical treatment. 8. Miscellaneous items. The laboratory has played a very important part in these experiments. Several pieces of laboratory apparatus which are not common in water purification laboratories are illustrated and described. These include a stirring machine, a laboratory sand filter, a turbidimeter, and a floc detector. With this equipment, water may be treated and filtered in the laboratory to duplicate with accuracy plant results. The loss of head curves for the filters with respective areas of 100 square feet, 10 square feet, and 2.46 square inches (laboratory filter) coincide very closely when filtering the same water and with all other conditions the same except the sand bed areas. The experimental work has shown the major problem to be the handling of the microörganisms so as to produce filter runs long enough for the practical operation of a large plant. The work has indicated that some other coagulant than aluminum sulphate will have to be used part of the time and also that filtration rates greater than 125,000,000 gallons per acre per day may be used. These results alone, if confirmed by future experiments, will result in savings which will more than justify the total cost of the experimental work.—*C. C. Ruchhoft (Courtesy Chem. Abst.).*

Disposal of Phenol Wastes from By Product Coke Plants. F. W. Sperr, Jr. Amer. Jour. Public Health, 19: 8, 901–907, August, 1929. The problem of the disposal of phenol wastes from by-product coke plants is shown to be due to the rapid growth of such plants, which have replaced the beehive coke ovens, and the universal practice of chlorination of public water supplies. It is shown that the sources of phenol at by-product coke plants are the gas liquor or weak

ammonia liquor, the so-called final cooler water or water which has been utilized for direct cooling of the gas, steam condensate from the distillation apparatus and from the benzol recovery plant, and miscellaneous spillages on floor and ground. It is stated that a by-product coke plant with a capacity of 1000 tons per day would produce about 500 pounds of phenol per day and 4 cents per pound might be considered a possible value, which would amount to $20.00 per day for this type of plant. This would not cover the cost of overhead and operation of phenol recovery plants, but probably would cover the cost of operation. Methods of phenol recovery or elimination are said to be as follows: disposal by complete evaporation on hot coke or blast furnace slag; reheating the ammonia liquor entering the ammonia still to drive off the phenols; extraction of the phenols with solvents; removal of phenols with solid adsorbents; and biological treatment, such as by mixture with sanitary sewage and treatment at the conventional sewage treatment plant, or through separate biological treatment on inoculated filters. The author concludes that all phenol bearing wastes, with the exception of ammonia still wastes, may be handled by installing recirculating systems to prevent phenols from such sources reaching water supplies. The cheapest and most satisfactory method of disposing of the ammonia still wastes consists of the discharge into city sewers, provided, that sufficient volume of sewage is available. Where this is not the case, the ammonia liquor should be treated for the removal of the bulk of the phenols. The disposal of ammonia still wastes by use for quenching coke is available as an emergency method, except in plants producing domestic coke. This method adequately protects water supplies but is unsatisfactory for many technical reasons.—*C. R. Cox.*

Chloro-Phenol Tastes and Odors in Water Supplies of Ohio River Cities. H. W. Streeter. Amer. Jour. Public Health, **19**: 8, 929–934, August, 1929. This very complete discussion of the paper on the Disposal of Phenol Wastes which appeared in the *Journal of the American Public Health Association* in July, 1929, summarizes extensive studies of engineers of the United States Public Health Service in the upper portion of the Ohio River drainage area upon this form of pollution and the resulting effect upon water supplies secured from the river. The data indicate that natural purification in the stream, presumably due to biochemical processes, removes most of the phenol in the water, especially when the water temperatures are high; thus accounting for the reduction in prevalence of phenol tastes as distance downstream from coke plants increases and also for seasonal variations in their relative frequency and intensity. It has been concluded, therefore, that when water supplies are subject to continuous or frequent pollution by phenolic wastes the sources of pollution are more likely to be found in the vicinity of the supply than at more distant points, so that more immediate benefit will result from the elimination of all sources of phenol located directly above water supply intakes.—*C. R. Cox.*

Iodine in Water, Food, and Urine. H. W. Clark and George O. Adams. Amer. Jour. Public Health, **19**: 8, 898–900, August, 1929. Reviews the results

of extensive studies of iodine content of various foods and waters in the state of Massachusetts. Typical results are as follows:

	Iodine parts per billion		
Soft-shell clams	1,012	1,152	—
Quahaugs	197	130	205
Flour	16	9	—
Fresh codfish	1,056	946	
Milk	17	—	—

The iodine content of various waters in the state of Massachusetts varies from 0 to 6.33 parts per billion. It is concluded, therefore, that the normal physiological requirements for iodine are supplied by food rather than by water.—*C. R. Cox.*

Filter Plant Rids Midland Water of Chemical Taste. Paul Stegeman. The American City, 41: 2, 90–91, August, 1929. The city of Midland, Michigan, originally secured water from a series of deep wells which furnished a highly mineralized water of objectionable taste. As a result, untreated water from Chippewa River was utilized for a short time to supply the city. The high turbidity and objectionable quality of this water led to the installation of a modern rapid sand filtration plant, consisting of combined baffling and mechanical agitator mixing basins, clarified with continuous sludge removal equipment, coagulation basins, rapid sand filters, and clear well. The water used, with a hardness of 115 to 225 p.p.m., is softened and coagulated by the use of calcium hydroxide and alum.—*C. R. Cox.*

System Applied to Meter Setting and Meter Records. E. G. Wilhelm. The American City, 41: 2, 103–105, August, 1929. This article reviews the various forms and tabulations utilized by the Williamsport Water Company.—*C. R. Cox.*

New Industrial Water Supply Brings Business. Anon. The American City, 41: 2, 137–138, August, 1929. The city of Aberdeen, Washington, installed a municipal water power plant and separate industrial water supply to attract paper mills to the city. The project entailed a bond issue of $1,600,000, which was considered warranted because immediately after the project was undertaken several large pulp and paper mills were located in the city. This industrial water supply system is capable of delivering from 80,000,000 to 120,000,000 gallons of water daily.—*C. R. Cox.*

The Control of Chlorination of Water Supplies. E. H. Parks. Monthly Bulletin, Indiana State Board of Health, 32: 3, 35, March, 1929. In sterilizing water we must feed enough chlorine to have, after a reasonable time for reaction, a measurable excess left. It is usually recommended that the residual chlorine content be kept above 0.1 p.p.m. and below 0.3 p.p.m. It is frequently desirable to apply the main chlorine dose as the water goes into the clear well

and a small secondary dose as it leaves it. Residual chlorine tests should be made as often as may be necessary to insure a residual at all times.—*G. C. Houser*.

Water and Sewage Works Development in Connecticut. W. J. Scott. Connecticut Health Bulletin, 43: 4, 121, April, 1929. In 1798 the first small water supply was developed in Durham. From 1850 almost up to the present time there was rapid growth in the number of public water supplies. The total number of waterworks is now 110, supplying 136 communities, which represent a population of about 1,350,000, or approximately 85 per cent of the total population of the state. About 21 per cent of the total population of the state receive water that is filtered, and 69 per cent receive water that is chlorinated. —*G. C. Houser*.

Epidemic of Typhoid Fever in Fort Wayne. Monthly Bulletin, Indiana State Board of Health, 32: 4, 51, April, 1929. An outbreak of acute gastroenteritis occurred in Fort Wayne during the last week of February, 1929, and was followed by 40 cases of typhoid fever in March and April. Search was made by the local water department for the cause, and a cross-connection was found between the city mains and the untreated river water, used by the Wabash R. R. for their boilers and fire protection. The inlet for this river water was a short distance below a sewer outlet. The cross-connection when found was open, and the pressure in the river water main very much higher than that in the city mains, so that the city water was being polluted with diluted sewage. —*G. C. Houser*.

A Costly Epidemic. Illinois Health Messenger, 1: 7, 27, April 1, 1929. On February 8 the Governor of New York signed a bill which authorizes the city of Olean to issue $350,000 in bonds to pay the damages and other costs growing out of a typhoid fever epidemic of 230 cases in that community during the summer of 1928. City responsibility for the outbreak, which was traced to pollution of the public water supply, was clearly established. The community has a population of about 27,000.—*G. C. Houser*.

Albany Loses Third Typhoid Suit. Health News (N. Y. State Dept. of Health), 6: 13, 50, April 1, 1929. On March 13, Albany lost its third damage suit brought as a result of a typhoid fever outbreak, when Mrs. Greenwald was awarded a verdict of $3600 for the death of her daughter from the disease. At the trial it was brought out that high water in the Hudson River overflowed into the old Erie Canal bed and that polluted water was drawn into the aqueduct running from the filtration plant to the pumping station. Subsequently the aqueduct was drained and leaks found About a dozen more suits based on like grounds are said to be pending.—*G. C. Houser*.

Gowanda Experiences Diarrhea Outbreak. Health News (N. Y. State Dept of Health), 6: 17, 68, April 29, 1928. Dr. R. M. Atwater, Cattaraugus county health officer, recently reported an outbreak of diarrhea in Gowanda. Report indicates that first estimate of 25 cases was undoubtedly lower than the

actual number. Dr. Atwater is of opinion that this outbreak was caused by gross pollution of the water supply from a field recently fertilized with manure.—*G. C. Houser.*

Installation of Public Water System Follows Typhoid Outbreak. Press Bulletin 249: Maryland Dept. of Health, May 6, 1929. In the late summer of 1928 a typhoid epidemic involving 37 cases occurred at Eastport, Md., a community of 2750 population. No public water supply or sewerage facilities were available. Private wells furnishing approximately 500 properties were of shallow depth, and after a storm resulting in excessively high tides, accompanied by heavy rains, the outbreak occurred. Plans were put into operation for the installation of a public water supply system; the water to be drawn from the Annapolis supply, and within 4 months after the outbreak occurred the entire distribution system had been installed.—*G. C. Houser.*

Court Decision Assures Filtration Plant for Lockport. Health News (N. Y. State Dept. of Health), 6: 21, 84, May 27, 1929. After much opposition the city of Lockport, N. Y., apparently can now proceed to build a modern filtration plant to treat the water of Niagara River. Latest decision was affirmation by supreme court of mandamus order, directing city council to issue bonds for construction of plant. When this work is completed, all cities and villages taking water from Niagara River will have up-to-date purification systems.—*G. C. Houser.*

Supreme Court of Ohio Sustains Authority of State Health Department. Monthly Bulletin, Indiana State Board of Health, 32: 5, 68, May, 1929. State Health Dept. ordered the city of Bucyrus to cease pollution of Sandusky River by discharging sewage into that stream. Upon appeal by the city, the Ohio Supreme Court declared in no uncertain terms the sovereignty of the state over municipalities in respect to sanitation and protection of public health. The court also overruled a demurrer of the city of Delphos to a petition for a writ of mandamus filed by State Department of Health to compel that city to comply with an order requiring certain improvements in its methods of handling sewage for the prevention of stream pollution.—*G. C. Houser.*

The Old Swimming Hole and the New. I. M. Glace. Pennsylvania's Health, 7: 3, 15, May–June, 1929. Among the recommendations of Joint Committee on Bathing Places appointed by Conference of State Sanitary Engineers and American Public Health Association are the following in regard to quality of water. *Bacterial count on agar at 20°C.*; not more than 10 per cent shall exceed 1000 per cc., with no single sample over 5000 per cubic centimeter *B. coli*; not more than 2 out of 5 10 cc. samples collected on same day shall show positive presumptive test. *Excess Chlorine* shall be between 0.1 and 0.5 p.p.m. Water shall have alkaline *reaction* at all times. *Temperature* of water not over 72°F.—*G. C. Houser.*

Mobile Water and Sewage Laboratory. Illinois Health Messenger, 1: 13, 52, July 1, 1929. In order to meet increasing demands for work and tests on water-purification and sewage-treatment plants and polluted streams, the

Illinois Department of Public Health will have available in the near future a fully equipped mobile laboratory fitted out with all necessary water and sewage laboratory equipment, apparatus, and supplies, so as to permit complete chemical, bacteriological, and biological work to be done in the field.—*G. C. Houser.*

Investigation of the Water Resources of Connecticut. Conn. Health Bulletin, 43: 7, 160, July, 1929. The Connecticut state water commission has recently been authorized by the legislature to collect, classify, and file information and data relative to the water resources located within the state, including surface and underground waters, and to prepare reports upon the best methods of utilizing such resources. Ten thousand dollars has been appropriated for the purpose, and the commission's report is due in January, 1931. —*G. C. Houser.*

Rules Passed by Indiana State Board of Health. Monthly Bulletin, Ind. State Bd. of Health, 32: 7, 101, July, 1929. Among the rules passed since October 1, 1928, are the following: an order requiring the submission of water supply plans to the state board of health for its approval; a regulation requiring the construction and use of sewers and sewerage facilities in incorporated cities and towns where the lack of such facilities, or the failure to use them, results in the production of conditions causative of disease; sanitary regulations for camps; swimming pool regulations. Among the last-named is the provision that the quality of the water must be such that the total colonies on standard agar media incubated for 24 hours at 37.5°C., must not exceed 1000 per cubic centimeter and *B. coli* must not be confirmed in more than one-half of the 1 cc. portions of water.—*G. C. Houser.*

The Present Typhoid Fever Problem. Illinois Health Quarterly, 1: 3, 129, July–September, 1929. Typhoid fever is far more prevalent in the extreme southern portion of Illinois than elsewhere in the state. The worst typhoid conditions prevail in communities of intermediate size. Here we have populations large enough to involve frequent exposure to many people, some of whom are typhoid carriers. At the same time the communities frequently have not installed sewer systems nor do they enjoy sanitary water supplies. Furthermore, there is little or no sanitary supervision over milk supplies.—*G. C. Houser.*

Discharge of Trade Wastes from an Economic Standpoint. W. Rudolfs. Public Health News (New Jersey Dept. of Health), 14: 9, 196, August, 1929. Industrial wastes play an important part in stream pollution. There are two ways of treating industrial wastes before discharge: (1) allowing the industrial waste to be led into the town's sewers and treating the mixture in a disposal plant; and (2) treating the industrial waste at or near its source. The treatment problem involves utilization of the wastes within the industry and treatment of the residual waste after as complete utilization as possible. Although the state should be in a position to direct investigations, the major cost of development of treatment processes should be borne by the industries. —*G. C. Houser.*

Discharge of Industrial Wastes from a Public Health Standpoint. H. P. Croft. Public Health News, (N. J. Dept. of Health), **14**: 9,202, August, 1929. Control of stream pollution is by police power delegated to New Jersey State Department of Health. The discharge of industrial wastes, in many instances, affects adversely the public health and comfort. At the legislative session of 1928, a bill was introduced authorizing the Agricultural Experimental Station and the Department of Health of the State to investigate industrial wastes treatment, but the bill was not passed. Continued effort should be made to combine State service with police power in dealing with pollution of waters by industrial wastes.—*G. C. Houser*.

Court Decision Upholds Prohibition of Bathing in Wallingford Public Water Supply. Connecticut Health Bulletin, **43**: 8,291, August, 1929. A recent decision relative to the $100,000 suit of the Harvey Realty Company of New Haven against the Borough of Wallingford is of interest. The plaintiff's claim for damages and a permanent injunction restraining the defendants from interfering with bathing in Pine Lake was denied. Pine Lake is a source of water supply for Wallingford. The borough's claim for an injunction to restrain the plaintiff from polluting the waters of the lake was denied because in the opinion of the court such an injunction was unnecessary.—*G. C. Houser*.

Mineral Waters as Therapeutic Remedies. Health News (N. Y. State Dept. of Health), **6**: 32, 127, August 12, 1929. Governor Roosevelt called to the attention of the Annual Conference of Health Officers and Public Health Nurses the fact that scattered all over this country are mineral springs, many of which have been considered beneficial to health. Only one, Hot Springs, Ark., has been developed in a scientific manner that will enable people to get the true therapeutic value from the use of the waters. The Governor has recently appointed a commission to study and report on the potentiality of Saratoga Springs as a health resort.—*G. C. Houser*.

Responsibility of the Health Officer for Safeguarding Water Supplies. Health News (N. Y. State Dept. of Health), **6**: 34, 133, August 26, 1929. Quotes a paper by Dr. Richard Slee to the effect that, irrespective of who may be legally in charge of a given water supply, the interested health officer should at all times keep himself thoroughly conversant with actual operations. He should independently keep tab on the bacteriological make-up of the supply as delivered to his people and be on the alert for the first indication of outbreaks of intestinal diseases. Whenever the source of his supply is known to be continuously badly contaminated, even though it may be filtered and chlorinated, he should labor to secure a cleaner, safer original source.—*G. C. Houser*.

The Shavers End Reinforced Concrete Service Reservoir. Robert A. Robertson. Water and Water Eng., **31**: 266, 249–256, June 20, 1929. This article is is primarily a description of concrete construction work. At Shavers End, England, it was necessary to increase capacity by construction of two additional wells, a new steel main 7½ miles long, and the reservoir described. Among the subjects covered by the writer are reservoir design, details of roof construction, special reinforcement forms, construction of the reservoir floor,

shuttering, joints, and finishes. Statistical data, such as excavation quantities, amounts of metal, and the like are given.—*Arthur P. Miller.*

The Testing of Water Meters. Anon. Water and Water Eng., 31: 366, 257–259, June 20, 1929. A manufacturer of meters, in connection with the erection of new shops, has built a large testing plant. All sizes of meters can be tested under conditions approximating those to be expected during actual operation. Venturi meters, up to the rate even of 750,000 gallons per hour, can be checked; the arrangement consisting of a closed circuit, thereby conserving the water, which is stored in a tank under the plant. In the flumes leading the water from the meters tested, baffles have been installed to reduce the velocity of approach to the weir. They are so efficient as to cut down that velocity to less than six feet per second. The water over the weir is measured by a hook gauge, permitting readings to within 0.001 of an inch.—*Arthur P. Miller.*

The Significance of B. coli in Water. GEORGE BAXTER. Water and water Eng., 31: 366, 262–264, June 20, 1929. Although a few years ago water was considered safe for domestic use if *B. coli* was absent in one cubic centimeter, more recent bacteriological opinion seems to indicate that no water can be considered satisfactory for domestic use unless free from *B. coli* in 50, or even in 100 cubic centimeters. Since probably almost no raw surface water is consistently free from *B. coli* in 10 cc., this higher standard implies that no surface water is satisfactory without some treatment. The cities of Glasgow, Manchester, and Dundee, having a total population of over 3,000,000, have been using unfiltered water for more than 50 years, and in the case of Dundee, *B. coli* is seldom absent in 5 cubic centimeters. Notwithstanding this, the incidence in these cities of diseases belonging to the water-borne group during that period will compare favorably with that in cities using filtered water. As a matter of fact, during the period referred to there has not been a single case of disease attributable to the water supply. The writer suggests, therefore, that too much significance is attached to *B. coli* as an indicator of pollution of a pathogenic nature. The city of Dundee carried out some experiments to show the possibility of *B. coli* pollution from gulls. Results were such that it was not unreasonable to assume that 100 gulls could so contaminate a reservoir of 100,000,000 gallons that a positive reaction for *B. coli* could be obtained in 40 cubic centimeters; or, with 500 gulls, in 8 cc. A comparison is made between the standard for water and that laid down by the Scottish Board of Health Milk Order for 1923. In the case of Grade A milk it is required that *Bacillus coli* should not be found in 0.01 cc., while in the case of Grade A pasteurized, the limit is 0.1 cc. When it is considered that milk has a greater scope for and risk of infection from disease-producing organisms, than water, the writer suggests that it in inconsistent to lay down higher standards for water than for milk, in so far as *B. coli* content is concerned. Further, the inference is drawn that when the water supplies of Glasgow, Manchester, and Dundee are compared with the standards for milk set up, it is impossible to avoid the conclusion that the presence of *B. coli* in 5 or even in 1 cc. does not indicate a condition incompatible with safety to health.—*Arthur P. Miller.*

NEW BOOKS

Proceedings of the Third Annual Conference, Maryland Water and Sewerage Association, Salisbury, Md., May 14 and 15, 1929. 146 pp. Methods and Costs of Water and Sewer Construction in the Washington Suburban Sanitary District. H. R. DEVILBISS, Department Engineer, 5–32. Brief outline of the organization of the engineering activities is given. During the past 10 years the organization has constructed or supervised the construction of 190 miles of 1¼- to 24-inch water lines, 130 miles of 6- to 30-inch sewer lines, two water filtration plants and pumping stations, a sewage disposal plant, and many other sanitary works. Construction equipment consists of 12 trucks, 4 trenching machines, 4 backfilling machines, 3 air compressors, 1 truck-mounted crane, 4 tractors, 8 pumps, and other miscellaneous items. In water main construction, sand cast deLavaud centrifugal, sand spun centrifugal, and McWane horizontally cast pipe have been used. Joints are made of braided hemp packing and leadite. Hydrants are of special design. Copper tubing is used for services ¾ to 1½ inches in diameter. The following data summarize the lengths and costs of water pipe laid by day labor in 1927 and 1928.

SIZE	1927		1928	
	Feet laid	Cost per foot	Feet laid	Cost per foot
inches		*dollars*		*dollars*
2 and less	1,607	1.272	1,508	1.364
3	640	1.870	475	2.428
4			2,568	1.435
6	21,971	2.134	38,592	1.761
8	11,455	2.887	31,436	2.130
10	6,817	3.394	9,480	2.648
12	5,853	4.176	4,974	4.188
16	4,252	4.863	863	4,103
20	648	8.451		
Totals and averages...	53,243	2.947	89,896	2.128

Similar data are given for sewer construction. In the discussion of this paper the elements contributing to the saving in the use of 16-foot instead of 12-foot length cast iron pipe are pointed out. Well Water Supplies—Discussion of Condition and Types on Eastern Shore of Maryland. W. R. SPRING, 59–62. Statement of the geographical, topographical, and geological conditions of the larger wells. Layne-Atlantic Wells. R. R. SCHWEITZER, 63–68. A consideration of the various types of water wells and an explanation of the advantages of the gravel wall type well. The Kelly Concrete Well. E. W. BENNISON, 69–74. A discussion of well casing materials and the hydraulic design of well screens. The Selection of Pumping Equipment for Well Supplies. E. G. KASTENHUBER, JR., 75–82. The author formulates his practice in the planning of

well water supplies for the small towns of the Eastern Shore of Maryland with populations generally less than 500 persons: (1) Where source of supply is one deep well and the water level at desired pumping capacity is below direct pump action: (*a*) Airlift to ground level and two (if funds permit) triplex plunger pumps, either engine or motor driven depending upon availability of electric current and its cost, pumping to tank or other storage direct through mains. (*b*) Airlift to maximum elevation above ground level up to ten feet and two low speed centrifugal pumps with suction at near bottom level of reservoir so as to act practically as submerged pumps and obviate priming trouble. (2) Where source of supply is one deep well with water at desired pumping capacity within direct pumping action: Either motor or engine driven triplex plunger pumps (two units if possible) pumping direct to tank through mains. (3) Where source of supply is two or more wells either deep or shallow with water level below direct pumping station: (*a*) Deep well turbine pumps (if electric power is available) delivering direct to tank through mains. (*b*) Airlift to ground level and engine driven triplex plunger pumps delivering direct to tank through main. In all of the foregoing it it so be assumed that only small diameter (4½- to 8-inch) wells are being used as a source of supply. The newer developments of large diameter wells using appropriate pumping equipment are usually too expensive to deserve consideration in the small town installations with which the writer is familiar and to which he has devoted time and study. The point in favor of airlifts is the fact that frequently the quality of the water is substantially improved by aëration made possible by this method of two-stage pumping. **Discussion:** CARL A. HECHMER points out merits of several types of pumping equipment and favors use of centrifugal instead of triplex pumps. WALTER C. MUNROE advises the collection of all possible pertinent data upon the groundwater conditions before drilling wells and determining upon type of pumping equipment; for deep well pumping equipment he prefers, first, the centrifugal or turbine type; second, the airlift, and last, the plunger type. **Landscape Treatment of Surroundings of Water and Sewage Plants.** G. W. STEVENS, Jr., 83–88. [This paper is principally concerned with the landscaping of sewage treatment plants, but the fundamental principles will apply equally well to water plants. ABSTR.] Four dominant qualities of artistic landscaping are unity, variety, character, and finish. **The Control of Filter Washing.** EDWARD S. HOPKINS, 89–95. The belief of many plant operators that the generally accepted washing rate of 2 feet vertical rise per minute is not sufficient was the motive for studies of the relation between washing characteristics and the maintenance of clean beds with long periods of operating service. These studies indicated that a 4-minute wash at 2.7 feet vertical rise per minute is the most economical procedure. The turbidity of the wash water at the end of the washing period should not exceed 75 p.p.m. The author points out a most important fact to be borne in mind "that these conclusions may not strictly apply elsewhere, due to various characteristics of plant design." **Discussion:** J. M. JESTER believes velocities higher than 2.5 feet vertical rise per minute are impractical, especially with filter having umbrella strainer system, because of loosening of strainers from laterals. He advocates closer spacing of wash troughs to reduce formation of mud balls. S. T. POWELL believes that the formation of mud balls cannot be

prevented by the application of wash water at high rates, but that the closer spacing of wash troughs will have a beneficial effect. **The Typhoid Fever Outbreak at Eastport and the Relief Measures Applied.** F. W. CASPARI, 96–107. A graphic description of the investigations, surveys, and consequent construction within four months of a water distribution system as a remedy for a typhoid epidemic. **Discussion:** S. J. MORIARTY describes the investigation made of sources of milk, ice cream, ice, water, and vegetables as a bsais for the conclusion that water was the means of transmission of the epidemic. W. C. MUNROE describes the construction of the water distribution system. **Aërial Surveys for Municipal Improvements.** WM. D. TIPTON, 108–119. The author points out the many applications of aërial surveys to municipal planning, e.g., tax maps, zoning maps, base maps, house counts, city planning, surveys for acquisition of property, and estimates of direction of growth. The mechanics of aërial plane photography and the means employed to eliminate the many factors which introduce errors are discussed. The accuracy of the final mosaic is said to be excellent. **The Design of Salisbury's Water and Sewer Systems.** G. B. LEONARD. 120–131. Salisbury has a population of about 9000 in 1924. Groundwater supply was developed by means of six concrete wells. Three low-service pumps of 1000-, 1500-, and 2000-g.p.m. capacity were planned to deliver the water from wells to aërators for removal of CO_2, and thence into a reinforced concrete storage reservoir of 500,000 gallons capacity. Three high service pumps of 1000-, 1500-, and 2500-g.p.m. capacity were planned to deliver into the distribution system, consisting of looped 12-inch arteries laid 2,000 to 3,000 feet apart subdivided by 8- and 10-inch mains and a gridiron of 6-inch mains. A 200-h.p. Diesel engine driving a 125-k.v.a. generator was planned for standby service. **Discussion:** F. H. DRYDEN. Water works improvements, including acquisition of private water company, cost $415,000. Present average daily water consumption is 0.6 m.g.d. and maximum, 1.0 m.g.d. Average cost of pumping water during past year, including salaries, power, and maintenance of buildings and grounds is 3¼ cents per 1000 gallons or 25 cents per million gallons lifted 1 foot high. Accurate costs were kept of water main construction from August 1925, to June 1928. The costs per foot of 6-inch cast iron water mains built by three methods were:

Contractor furnishing all labor and material	62 cents
Contractor furnishing all labor; City furnishing all material	37 cents
City furnishing all labor and material	25 cents

ROBERT B. MORSE. The lack of extensive water and sewerage systems in Salisbury was fortunate in permitting a more or less independent design of the new system. *Question Box.* 132–142. *What publicity should a water system seek? How should it be obtained? Do you have any program of publicity?* Smaller plants appear not to advertise; larger ones do indirectly by encouraging visits by school children. *Is it advisable to have local legislation compelling property abutting public water and sewer systems to connect thereto?* General opinion favors such legislation, but indicates that, in general it is not enforced except as a last resort. *What are the advantages of setting meters outside?*

Advantages are registration of leakage on property, prevention of connections outside of meter, reduced damage from hot water. Disadvantages are freezing and increased cost of setting. *Are copper service pipes detrimental to health?* There appear to be no detrimental effects. *What constitutes a proper inspection of valves and fire hydrant valves? Valves*—Semi-annual inspection advisable although Fire Underwriters' requirement is yearly inspection. Covered valve boxes should be brought to grade; all boxes cleaned of débris. Set valve key on nut; pour kerosene or diluted crank case drawings down valve key; oil will run down the valve stem, lubricate it, and revive packing. Operate valve up and down, thereby cleaning groove of sediment and rust which is pushed out sides of groove. Count number of turns; same for same make and size. This will bring to light bent valve stems or débris under gate without actually closing down main. Grease gears on large valves; clean teeth of gears with wire brush. *Fire Hydrants*—Physical examination of hydrant first; condition of operating nut, nozzle threads; general appearance. Turn on water with all caps on; listen with aquaphone for leaks in drain valve or hydrant barrel; note if all nozzle caps are tight in hydrant; measure static pressure by placing one cap on hydrant with pressure gauge attached. Turn off water; remove nozzle cap and note rate of drainage. Flush out hydrant noting residual pressure on one nozzle and rate of flow with pitot tube gauge. *What constitutes a proper protection of a watershed of a water supply?* Protection of watersheds is practically limited to those of moderate or small size. Ownership and strict sanitary control is most desirable and should be applied in so far as is practical.—*R. L. McNamee.*

Die Tierwelt der unterirdischen Gewässer. (The Fauna of Underground Waters.) P. A. CHAPPIUS. **Vol. 3 of A. THIENEMANN's Die Binnengewasser.** Pub. by E. Schweizerbartsche Verlagsbuchandlung, Stuttgart, 1927. Book is divided into (*a*) general discussion; (*b*) description of subterranean fauna; (*c*) biological modifications. The origin of underground water is discussed. Animals are found chiefly in artesian walls, hot and mineral springs, and underground rivers in limestone districts. The greater part of the fauna are invertebrates; oligochaetic worms, leeches, many snails, many interesting species of crustaceans, water spiders, and several insects. There are also certain endemic species of fishes and amphibians. The influence of the underground conditions on the modification of form, suppression of eyes, loss of colour, etc., is treated in the biological part and the position of the underground fauna in the story of evolution is discussed.—*M. H. Coblentz* (*Courtesy of the Department of Scientific and Industrial Research, Water Pollution Research Board, Summary of Current Literature*).

Welding: A Practical Treatise on the Application of Electric, Gas and Thermit Welding to Manufacturing and Repair Work. GEORGE W. CRAVENS and F. D. BLANCH. Chicago: American Technical Soc. 180 pp. From Chem. Abst., 23: 2143, May 10, 1929.—*R. E. Thompson.*

The Prest-O-Weld Manual; Instructions for Welding and Cutting by the Oxyacetylene Process. New York, Chicago, etc.; Oxweld Acetylene Co. 146 pp. From Chem. Abst., 23: 2143, May 10, 1929.—*R. E. Thompson.*

Welding Encyclopedia. 6th. ed. L. B. MACKENZIE and H. S. CARD. Chicago: Chicago Welding Engineer Pub. Co. 496 pp. $5. From Chem. Abst., 23: 3200, July 10, 1929.—*R. E. Thompson.*

Der Eisenwasserbau. H. KULKA. Berlin: Ernst und Sohn. 323 pp. M. 29. Reviewed in Génie civil, 93: 368, 1928. From Chem. Abst., 23; 2777, June 10, 1929.—*R. E. Thompson.*

Public Utility Service and Discrimination: Managerial Problems, Regulations and Practices. ELLSWORTH NICHOLS. Rochester, N. Y.: Public Utilities Reports, Inc. Cloth; 6 x 9 in.; pp. 1087. $10. Reviewed in Eng. News-Rec., 102: 1003, June 20, 1929.—*R. E. Thompson.*

The Municipal Year Book for 1928. Edited by EDWIN C. FAIRCHILD. London: The Municipal Journal. Cloth; 6 x 9 inches; pp, 1132. 20s. Reviewed in Eng. News-Rec., 102: 1005, June 20, 1929.—*R. E. Thompson.*

The Empire Municipal Directory and Year Book 1929–30. London: Municipal Engineering. Cloth; 6 x 10 inches; pp. 321. 12s. 6d. Reviewed in Eng. News-Rec., 102: 1005, June 20, 1929.—*R. E. Thompson.*

Die Theorie Der Gewichtsstaumauern unter Rucksicht auf die neueren Eergebnisse der Festigkeitslehre. K. KAMMÜLLER. Berlin: Julius Springer. Paper; $5\frac{1}{2}$ x $8\frac{1}{2}$ inches; pp. 60. 5.4 marks. Reviewed in Eng. News-Rec., 103: 108, July 18, 1929.—*R. E. Thompson.*

Engineering for Masonry Dams. WILLIAM PITCHER CREAGER. 2nd. Edition. New York and London: John Wiley & Sons, Inc. Cloth; 6 x 9 inches; pp. 294. $4. Reviewed in Eng. News-Rec., 103: 110, July 18, 1929.—*R. E. Thompson.*

Valuation of Public Service Corporations: Legal and Economic Phases of Valuation for Rate Making and Public Purchase. ROBERT H. WHITTEN. Revised and enlarged by DELOS F. WILCOX. 2nd. edition. **Vol. 1. Physical Property—Just Compensation. Vol. 11. Overheads—Intangibles—Depreciation —Rate of Return.** New York: The Banks Law Publishing Co. Cloth; 6 x 9 inches; pp. 2081. $30. Reviewed in Eng. News-Rec., 103: 108, July 18, 1929. —*R. E. Thompson.*

Welding Encyclopedia. 6th ed. L. B. Macmillan and R. S. Compton. Chicago: Welding Engineer Pub. Co. 500 pp. $5. From Chem. Abst., 23: 3200, July 10, 1929. R. E. Thompson.

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Public Utility Service and Discrimination: Managerial Problems, Regulations and Practices. Nathaniel T. Guernsey. Rochester, N. Y.: Public Utility Reports, Inc. Cloth; 6 x 9 in.; pp. 1025. $10. Reviewed in Eng. News-Rec., 101: 1025, June 20, 1929. R. E. Thompson.

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